YENEPOYA

(DEEMED TO BE UNIVERSITY)
Recognized under Sec 3(A) of the UGC Act 1956
Accredited by NAAC with 'A' Grade

YENEPOYA (DEEMED TO BE UNIVERSITY)

Deralakatte, Mangaluru - 575018

REGULATIONS AND CURRICULUM GOVERNING

POSTGRADUATE PROGRAM IN

MASTER OF SCIENCE BIOSCIENCE

(CURRICULUM - EFFECTIVE FROM 2017-18)

ATTESTED

Dr.Gangadhara Somayaji K.S.
Registrar
Yenepoya(Deemed to be University)
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YENEPOYA
UNIVERSITY

Recognized under Sec 3(A) of the UGC Act 1956 as per Notification No. F.9-11/2007-U.3 (A) dated 27th February 2008

Ref: No. YU/REG/ACA/ACM-30/2017 04.11.2017

The Dy. Director
Yenepoya Research Centre

Sub: Proposal to start M.Sc. in Biosciences from the academic year 2017-18

Ref: Decision taken at the 30th meeting of the Academic Council held on 20.10.2017, vide Agenda – 6

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The proposal to start M.Sc. in Biosciences course from the academic year 2017-18 has been approved in principle. The minor corrections suggested by the members may be incorporated and the final version may be sent to this office for further action.

(Dr. G. Shreekumar Menon)
REGISTRAR
mj

Copy to:

1. Vice Chancellor
2. CoE
3. Academic Section

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NOTIFICATION – 23/32-ACM/2018 dtd. 03.09.2018

Sub: Implementation of Choice Based Credit System in PG Program

Ref: Resolution of the Academic Council at its meeting held on 11.08.2018 vide agenda – 23

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The Academic Council at its meeting held on 11.08.2018, vide agenda – 23 approved the proposal to implement Choice Based Credit System in the following five PG programs which was subsequently ratified by the Board of Management.

1. M.S. W. (Master of Social Work)
2. M.H.A. (Master in Hospital Administration)
3. M.Sc. (Bioscience)
4. M.P.T. (Master of Physiotherapy)
5. M.P.H. (Master in Public Health)

The Regulations for the Choice Based Credit System in PG programs as recommended by the Faculty of Allied Health & Basic Sciences was also approved.

B.T. N

I/c REGISTRAR

mj Registrar
Yenepoya (Deemed)
University Road, Deralakatte
Mangalore - 575 018

Copy to:

1. Dean, Faculty of Allied Health & Basic Sciences
2. Principal, Yenepoya Physiotherapy College
3. The Coordinator, Choice Based Credit System
4. Dy. Director, YRC
5. HoD, Department of Public Health
6. HoD, Department of MSW
7. HoD, Department of Hospital Administration
8. Academic Section

Regulations, Scheme and Syllabus
Master of Science (MSc, in Bioscience)
Choice Based Credit System

Preamble

The broad goal of teaching and training of postgraduate students in M.Sc. Bioscience is to enable a student acquire sound knowledge in the subject and develop practical skills to contribute effectively in the fields of academics and research.

Yenepoya Research Centre has established several research facilities and has accumulated expertise in the frontier areas of life sciences, such as Stem cells and tissue engineering, Proteomics, genomics and metabolomics, bioinformatics, molecular biology, nanobiotechnology. The MSc course is envisaged under the centre's vision of knowledge dissemination in the broad area of Bioscience. And for offering this program, the centre has adequate human resources and expertise needed for offering the postgraduate course.

Master of Science (MSc.) in Bioscience is a post graduation course of Yenepoya Deemed to be University, Mangalore. The Choice based credit system to be implemented through this curriculum, shall allow students to develop a strong footing in the fundamentals and specialize in the disciplines of his/her liking and abilities.

The students pursuing this course would develop in depth understanding various aspects of the modern biology.

The new developments in medical/healthcare/pharmaceutical/research areas require skilled manpower with good theoretical knowledge.

The working principles, design guidelines and experimental skills associated with different fields of Biosciences help the students to pursue researches in field of recent and advanced areas like Stem Cell and Omics Technologies.

The learning healthcare environment in the campus will be very conducive for the learners to have practical exposure and understand the contemporary medical challenges that need research focus. The interdisciplinary setting at the Yenepoya research Centre shall allow the students to take courses from other postgraduate departments under the CBCS scheme.

General Regulation

1. Title of the programme:

   Master of Science in Bioscience (MSc Bioscience)

2. The commencement of the programme:
   August 2018.

3. Eligibility for admission:

   Bachelor's degree in any branch of Biological Science with a minimum of 50% marks in aggregate. Selection of candidates shall be on merit basis.

4. Duration of the programme:

   Two years with four semesters.

5. Course pattern:
   Choice based credit System with 4 semesters

Total credits:	96 credits
Core courses:	60 credits
Discipline specific electives:	6 Credits
Open elective papers-	6 credits
Project:	24 credits

1 credit=1 hour of lecture per week/ 2 hours of Laboratory or practical
Course pattern is given in Table 1.

2. Definitions of Key Words

i. Academic Year: Two consecutive (one odd + one even) semesters constitute one academic year.

ii. Choice Based Credit System: The CBCS provides choice for students to select from the prescribed courses (core, elective or minor or soft skill courses).

iii. Course: Usually referred to, as 'papers" is a component of a programme. The courses shall define learning objectives and learning outcomes. A courseshall comprise lectures/ tutorials/ laboratory work/ field work/ outreach activities/ project work/ vocational training/viva/ seminars/ term papers/assignments/ presentations/ self-study etc. or a combination of some of these.

iv. Credits: Credit defines the quantum of contents/syllabus prescribed for a course and determines the number of hours of instruction required per week. Thus, normally in each of the courses, credits will be assigned on the basis of the number of lectures/tutorial laboratory work and other forms of learning required, to complete the course contents in a 16-20 week schedule: One credit=1 hour of

lecture per week/ two hours of Laboratory or practical/three hours of clinical rotation, field work/posting. All courses need not carry the same credits.

v. Grade Point: It is a numerical weight allotted to each letter grade on a 10-point scale.

vi. Credit Point: It is the product of grade point and number of credits for a course.

vii. Cumulative Grade Point Average (CGPA): It is a measure of overall cumulative performance of a student over all semesters. The CGPA is the ratio of total credit points secured by a student in various courses in all semesters and the sum of the total credits of all courses in all the semesters. It is expressed up to two decimal places.

viii. Letter Grade: It is an index of the performance of students in a said course. Grades are denoted by letters: A+, A, B+, B, C, P and F.

ix. Semester Grade Point Average (SGPA): It is a measure of performance of work done in a semester. It is ratio of total credit points secured by a student in various courses registered in a semester and the total course credits taken during that semester. It shall be expressed up to two decimal places.

x. Transcript or Grade Card or Certificate: Based on the grades earned, a grade certificate shall be issued to all the registered students after every semester. The grade certificate will display the course details (code, title, number of credits, grade secured) along with SGPA of that semester.

4. Semesters

An academic year shall consist of two semesters;

Odd Semester 1^{st}& 3^{rd}	July/August to December/January
Even semester 2^{nd}& 4^{th}	January/February to June/July

5. Types of Courses

i. Core course: a course that should compulsorily be studied by a candidate as a requirement is termed as a core course this can be hard core or soft core.

ii. Open Elective: Generally a course which can be chosen from a pool of courses and which may be very specific or specialized or advanced or supportive to the discipline/ subject of study or which provides an extended scope or which enables an exposure to some other discipline or subject or domain or nurtures the candidates proficiency skill.

- The open elective courses shall be offered in the second and third semesters only.
- The list of open elective courses offered shall be displayed in the

university website.

- A student shall not take the courses offered by the department in which she/he is enrolled.
- Registration for the open elective courses shall be at least one week prior to the commencement of the course with the CBCS coordinator.

6. Attendance:

Each course (theory, practical, etc.) shall be treated as an independent unit for the purpose of attendance.

A student shall attend a minimum of 80% of the total instruction hours in a course including tutorials and seminars in each semester.

Table 1. Course Scheme of instruction and examination for Semester-wise

Course code	Type of Course	Course name	Hrs/ Week	Exam (hours)	IA Marks	SE Marks	Max marks	Credits
APBS101	Core -Theory	Biochemistry	4	3	40	60	100	4
APBS102	Core -Theory	Cell and Molecular Biology	4	3	40	60	100	4
APBS103	Core - Theory	Microbiology	4	3	40	60	100	4
APBS104a	Elective - Theory	Genetics	4	3	40	60	100	4
APBS104b		Genomics & Epigenetics						
APBS105	Core -Practical	Biochemistry	4	3	20	30	50	2
APBS106	Core -Practical	Cell and Molecular Biology	4	3	20	30	50	2
APBS107	Core - Practical	Microbiology	4	3	20	30	50	2
APBS108a	Elective - Practical	Genetics	4	3	20	30	50	2
APBS108b		Genomics & Epigenetics						
Total							600	24
	Second Semester							
APBS201	Open Elective	Environment and Health	3	3	40	60	100	3
APBS202	Core -Theory	Nanobiotechnology	4	3	40	60	100	4
APBS203	Core - Theory	Stem cell and Developmental Biology	4	3	40	60	100	4
APBS204	Core- Theory	Immunology	4	3	40	60	100	4
APBS 205	Core- Theory	Toxicology	3	3	40	60		3
APBS206	Core -Practical	Nanobiotechnology and Toxicology	4	3	20	30	50	2
APBS207	Core -Practical	Stem Cell and Developmental Biology	4	3	20	30	50	2
APBS208	Core - Practical	Immunology	4	3	20	30	50	2
Total							650	24
	Third Semester							
APBS301	Open Elective	Scientific Communication	3	3	40	60	100	3
APBS302	Core -Theory	Biostatistics and Bioinformatics	4	3	40	60	100	4
APBS303	Core - Theory	Systems biology and Omics Technology	4	3	40	60	100	4
APBS304	Core -Theory	Genetic Engineering	4	3	40	60	100	4
APBS305	Core- Theory	Cell culture Techniques	3	3	40	60	100	3
APBS306	Core -Practical	Biostatistics and Bioinformatics	4	3	20	30	50	2
APBS307	Core - Practical	Systems Biology and Omics Technology	4	3	20	30	50	2
APBS 308	Core -Practical	Cell culture techniques	4	3	20	30	50	2
Total							650	24
	SEMESTER –IV							
APBS401	Project work	Full time 14 weeks			100	300*	400	24

7. Assessment of a Course:

Evaluation for a course shall be done on a continuous basis. Two continuous internal assessments (CIA) followed by one semester end university examination (SEE) for each course. The components of CIA may include, sessional tests, Seminar/ Journal Cub/other related activities, Review/Assignment/Social involvement and other activities relevant to the course. The weightage of CIA shall be 40% and SEE shall be 60%.

7.1. Registering for examination:

Candidates having ≥80% attendance in each of the courses can only qualify to appear for the semester end examinations. The candidate shall register for all the papers in the subject of a semester when he/she appears for the examination of that semester for the first time.

7.2. Scheme of Examinations

i. Internal Assessment: Marks for internal assessment shall be awarded on the basis of seminars, Journal paper presentations, tests, assignments etc. The assessment gives importance to continuous and comprehensive evaluation. The internal assessment marks shall be notified be communicated to the Controller of Examinations before the commencement of the University examinations.

Components of CIA	Details	Weightage
Sessional Tests	Average of the two tests	10%
Seminar/ Journal Cub/other related activities	One Seminar/ course One Journal paper relevant to the core courses	15%
Creativity /Skill enhancing Exercise	Short project/ Blogs//Developing Experimental Video/outreach activities/other creative activities	10%
Review/Assignment/	Discipline specific as required by the course	5%

ii. Semester End Examination:

There shall be examinations at the end of each semester ordinarily during December/January for odd semesters and during June/July for even semesters. The SEE duration shall be three hours. Semester IV will be assessed on the project outcome.

Pattern of question paper for semester end examination

Sl. No	Key Criteria	No. Of questions and Marks	Max marks
1	Short questions (6 out of 8 questions)	6 X 2	12
2	Problems/concepts (4 out of 6 questions)	4 X 6	24
3	Descriptive problems/questions (2 out of 3 questions)	2 X 12	24
	TOTAL		60

Pattern for practical examination

Sl. No	Key Criteria	No. Of questions and Marks	Max marks
1	Major Experiment –Perform and report	1 X 14	14
2	Minor Experiment- Perform and report	1 X 6	06
3	Spotters- Identify and report	5 X 2	10
	TOTAL		30

CIA shall be based on the quality of the records and performance in laboratory practical sessions during the semester (20 Marks).

iii. Valuation of answer scripts:

a. Each theory examination shall be evaluated by one internal and one external examiner. There shall be a third evaluation if the difference is more than 15%.

b. Practical examination shall be jointly conducted and evaluated by one internal examiner and one external examiner.

iv. Evaluation of Project

The internal assessment marks shall be allotted by the supervisor based on the work progress and attendance.

Dissertation: Dissertation shall be evaluated by an external and internal examiner on the following criteria;

Sl. No	Key Criteria	Max marks
1	Outline of the work and adequacy of the methodology	40
2	Rationale of the study and Contribution to skill enhancement	40
3	Appropriateness of instruments and data analysis tools applied	60
4	Quality of data interpretations and reporting style	60
TOTAL		200

Viva-voce: Viva voce shall be conducted by a Common Viva-Board consisting of the Chairman (BOE), internal guide and one external expert as approved by the Controller of Examinations. Viva duration shall be of one hour for 100 marks.

Sl. No	Key Criteria	Max marks
1	Justification on the work done and its relevance	25
2	Clarity of presentation	25
3	Knowledge on the subject	25
4	Communication skills	25
TOTAL		100

8. Letter Grades

The results of successful candidates at the end of each semester shall be declared in terms of Grade Point Average (GPA) and alpha sign grade. The results at the end of the fourth semester shall be classified on the basis of the Cumulative Grade Point Average (CGPA) obtained in all the four semesters and the corresponding overall alpha-sign grade. The letter grade as described below shall be adopted.

Letter Grade	Grade Point	Range of marks
A+(Outstanding)	10	95-100
A (Excellent)	9	85-94
B+ (Very Good)	8	75-84
B (Good)	7	65-74
C (Average)	6	55-64
P (pass)	5	50-54
F (Fail)/ RA (Reappear)	0	Less than 50

9. Calculation of Cumulative Grade Point Average (CGPA):

The Cumulative Grade Point Average (CGPA) at the end of the fourth semester shall be calculated as the weighted average of the semester GPW. The CGPA is obtained by dividing the total of GPW of all four semesters by the total credits for the programme.

The following is the sample illustration of computing semester grade point averages (GPA), cumulative grade point average (CGPA) and the letter grades assigned.

CGPA Range	Letter Grade
9.0-10.0	A+(Outstanding)
8.0 – 8.99	A (Excellent)
7.0 - 7.99	B+ (Very Good)
6.0 - 6.99	B (Good)
5.5 - 5.99	C (Average)
5.0 – 5.49	P (pass)
<5.0	F (Fail)

10. Marks qualifying for a pass

i. A candidate shall be declared to have passed the PG program if he/she secures at least a CGPA of 5.0 (Course letter Grade P) in the aggregate of both internal assessment and semester end examination marks.

ii. For each course the total of 100% is determined from the CIA evaluation and the SEE weighted at 40% and aggregate of CIA and SEE at 50% as minimum for pass.

iii. The candidates who pass all the semester examinations in the first attempt in two years are eligible for ranks provided they secure at least a CGPA of 6.0 (at least letter Grade B).

iv. The results of the candidates who have passed the fourth semester examination but not passed the lower semester examinations shall be declared as NCL (Not Completed Lower semester examinations). Such candidates shall be eligible for the degree only after completion of all the lower semester examinations.

v. A candidate who passes the semester examinations in parts is eligible for only CGPA and letter Grade but not for ranking.

vi. Carry over shall be allowed for candidate who failed in not more than two courses in a semester.

vii. Candidate who fails in any of the unit/project work/Project Report/ dissertation shall reappear in that unit/project work/Project Report/ dissertation and pass the examination subsequently.

11. Re-Entry after Break of the study

a. Students admitted to a program abstaining for more than 3 months must seek readmission into the appropriate semester.
b. The student shall follow the syllabus in vogue (currently approved/is being followed) for the program
c. All re admissions of students are subject to the approval of the Vice- - Chancellor.

12. Maximum period for completion of the Programme

A candidate shall complete the four semesters (two years) programme within five years from the date of admission.

13. Detailed syllabus

Detailed syllabus enclosed as Annexure –I

Annexure 1: Syllabus

SEMESTER-I Courses and scheme

Course code	Type of Course	Course name	Hrs/ Week	Credits
APBS101	Core -Theory	Biochemistry	4	4
APBS102	Core -Theory	Cell and Molecular Biology	4	4
APBS103	Core - Theory	Microbiology	4	4
APBS104a	Elective - Theory	Genetics	4	4
APBS104b		Genomics & Epigenetics		
APBS105	Core -Practical	Biochemistry	4	2
APBS106	Core -Practical	Cell and Molecular Biology	4	2
APBS107	Core - Practical	Microbiology	4	2
APBS108a	Elective -Practical	Genetics	4	2
APBS108b		Genomics & Epigenetics		
Total				24

Course Name: BIOCHEMISTRY
Course Code: APBS101
Credits: 4 (56 hours)

Course objectives:
At the end of the course the student will be able to

- Demonstrate their understanding of biochemical phenomena
- Show an appreciation of the breadth of material covered in modern biochemistry
- Describe mechanisms of biochemical processes.
- Demonstrate an understanding of the significance of biological specificity at the molecular level.
- Relate biochemistry to cellular and organismal processes.

Unit 1:Chemistry of Biomolecules 10 hrs

Chemistry of Biomolecules (carbohydrate, protein, lipids, nucleic acids), Carbohydrates: classification, basic chemical structures, general reactions and properties, biological significance.
Lipids: classification, structure and function of major lipid subclasses. Formation of micelles, monolayers, bilayer.
Amino acids: classification, properties and reactions (N/C terminal reactions, ninhydrin reaction).
Digestion and absorption. Vitamins and Coenzymes: Classification, water-soluble and fat-soluble vitamins, coenzyme forms and their significance. Enzymes: Classification, nomenclature and properties,
Enzyme kinetics-one substrate reaction (Michaelis-Menten Equation). Factors affecting enzyme activity. Enzyme inhibition. Allosteric enzymes. Isozymes (LDH).

Learning outcome:

By the end of this unit, the student will be able to differentiate the biomolecules and their importance in the biological system

Unit 2: Analytical Biochemistry 12 hrs

Concept of pH, dissociation and ionization of acids and bases, pKa, buffers and buffering mechanism, Henderson Hasselbalch equation, ionization of amino acids and proteins, measurement of pH.
General principle and different types of chromatography, Electrophoresis: Moving boundary and zonal electrophoresis, paper and gel electrophoresis, PAGE and SDS-PAGE, isoelectric focussing technique.
Sedimentation: sedimentation velocity, preparative and analytical ultracentrifugation techniques, differential and density gradient centrifugation, subcellular fractionation.
Basic principal of radioactivity, spectrophotometry: Beer-Lamberts law, extinction coefficient and its importance, design of colorimeter and spectrophotometer, applications of uv-vis spectrophotometry.

Learning outcome:

By the end of this unit, the student will be able to know the importance of pH in normal physiological condition. They are also get mastered with all the techniques involved in biological sciences

Unit 3: Metabolism 10 hrs

Concepts of metabolism (carbohydrate metabolism, lipid metabolism, amino acid metabolism) Metabolic pathways- catabolic and anabolic, regulation of metabolic pathways.
Glycolysis; energetic and its regulation; PFK, gluconeogenesis carbohydrate metabolisms: Glycogen biosynthesis and its regulation.
Role of enzymes in synthesis and degradation of glycogen, role of cAMP. Citric acid cycle: energetics, regulation and significance,
Role of PDH. Electron transport chain and oxidative phosphorylation., biological oxidation, oxidative phosphorylation, Heme metabolism, Purine and Pyrimidine metabolism, acid base balance and disorders detoxification.
Basic law of thermodynamics, internal energy, enthalpy, entropy, concept of free energy, redox potentials, high energy compounds, structure and function of ATP.

Learning outcome:
By the end of this unit, the student will be able to know the importance of metabolic pathways and law of thermodynamics.

Unit 4:Enzymology 12 hrs
Isolation and purification, Classification and nomenclature of enzymes. Enzyme catalysis: enzyme specificity and the concept of active site, determination of active site.

Stereospecificity of enzymes. Enzyme kinetics: Factors affecting rates of enzyme catalyzed reactions, unisubstrate reactions, concept of Michaelis - Menten, Briggs - Haldane relationship,

Determination and significance of kinetic constants, catalytic rate constant and specificity constant, Limitations of Michaelis-Menten Kinetics.

Reversible and irreversible inhibition, competitive, non competitive and uncompetitive inhibition.

Mechanism of enzymes action: mechanism of action of lysozyme, chymotrypsin, carboxypeptidase. Multienzyme system, Mechanism of action, regulation and coenzymes of pyruvate dehydrogenase and fatty acid synthetase complexes. Allosteric enzymes.

Learning outcome:

By the end of this unit, the student will be able to know the importance of enzymes. Students will be thorough with enzyme kinetics and mechanism of action of enzymes

Unit 5: Nutritional & Clinical Biochemistry 12 hrs

Food calories, Respiratory quotient, Basal metabolic rate, Calorie requirement, Adult consumption unit, Nutritional aspects of Proteins, carbohydrates, lipids, vitamins and minerals.

Balance diet. Disorders related to the nutrition -Protein energy malnutrition, Starvation, obesity.

Collection and preservation of biological fluids and their significance, chemical analysis of CSF and its significance.

Disorders of carbohydrate metabolism, Postprandial and Glucose tolerance test. Biochemical changes in diabetes mellitus, Hypoglycemia, Ketone bodies. Lipids, lipoproteins and apolipoproteins-role in diseases.

Evaluation of organ function tests of gastric, pancreas, kidney and liver. Bilirubin, direct and indirect Vanderwal tests and their clinical significance, jaundice.

Fatty liver, Bile pigments - chemical nature and physiological significance. Porphyrins chemistry and disorders, structure of Hb, derivatives and abnormal Hb. Detection by spectrophotometry and by fluorescence.

Enzymes in differential diagnosis of diseases and their clinical significance. Detoxification, phase I and phase II reactions, Enzymes of detoxification.

Learning outcome:

By the end of this unit, the student will be able to know the nutritional values of proteins, carbohydrates, lipids, vitamins and minerals and their importance in the biological systems.

Recommended books for reference

1. Biochemistry Ed Lubert Stryer. W.H. Freeman and Company, New York.
2. Principles of Biochemistry. Ed Lehninger, Nelson and Cox. CBS publishers and distributors.

3. Harper's Biochemistry. Ed. R.K. Murray, D.K. Granner, P.A. Mayes and V.W. Rodwell. Appleton and Lange, Stamford, Connecticut.
4. Textbook of Biochemistry with Clinical Correlations. Ed. Thomas M. Devlin. Wiley-Liss Publishers.
5. Tietz Textbook of Clinical Chemistry. Ed Burtis and Ashwood. W.B. Saunders Company.
6. Principles and techniques of practical biochemistry. Ed Keith Wilson and John Walker. Cambridge University Press.
7. Biochemistry. Ed Donald Voet and Judith G. Voet. John Wiley & sons, Inc.
8. Molecular Cell Biology, H. Lodish, A. Berk, S.L. Zipursky, P. Matsudaira, D. Baltimore, J. Darnell
9. Bio-technology 1st edition. U. Satyanarayan. Books & Allied Publisher (p) Ltd. Kolkata.
10. Biochemistry of Signal Transduction and Regulation. 4th Edition. Gerhard Krauss Copyright c 2008 WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim ISBN: 978-3-527-31397-6

Course Name: CELL AND MOLECULAR BIOLOGY
Course Code: APBS102
Credits: 4 (56 hours)

Course objectives:

At the end of the course the student will be able to;

- Appreciate a single cell as a complete system, understand the importance of the genetic material, its arrangement and package
- Have clear idea about central dogma, (replication, transcription, translation), post translation and functionality of the genetic material
- Correlate the link between genetic material and diseased state and the importance of gene therapy.

Unit 1:Introduction 10 hrs

The Cell: An overview, cell communication and cellular respiration. Cell membranes and transport.
Cell division- Mitosis and Meiosis, Cell cycle- different phases, cell cycle arrest, cytokines, growth factors, apoptosis, necrosis, senescence.
Types of cells- stem cells, quiescent cells, cellular differentiation, structural features and characteristics.
Sub cellular fractionation, ultra centrifugal analysis, flow cytometry, FISH.

Learning outcome:
Students will be able to understand the molecular players for sustaining and functioning of the smallest unit- The Cell. They will also develop and idea on the sub cellular organelles.

Unit 2: Genome 12 hrs

History of molecular biology.
Genome organization: Genome overview at the chromosome level- eukaryotic and bacterial chromosomes, nucleus, nucleolus, centromeres, telomeres, chromatin. Histones and nucleosomes, chromosomes in cell cycle, gene, genome, gene dosage, genome size, repetitive DNA contents of genome, mobile DNA elements.
DNA Structure and types, Replication, enzymes and protein factors, cellular control.
Cell cycle check points, check points (S-phase, G2 phase, M phase), DNA repair, SOS response.
Eukaryotic genome C-value paradox, Repetitive DNA, General concept of a gene, Gene families, Non-coding genes, classical experiments in molecular genetics, genetic material, molecular structure of genes.

Learning outcome:
Students will be able to understand and appreciate the importance of the genes and the genetic material, its structure, arrangement and maintenance through several divisions.

Unit 3:Transcriptome 12 hrs

Transcription (prokaryotes and eukaryotes) and its regulation, RNA polymerase, transcription factors.
Differences between prokaryotic and eukaryotic transcription, post transcriptional modification of mRNA, tRNA, rRNA, RNA splicing, spliceosome machinery, types of splicing, exon shuffling, catalytic RNAs, RNA editing.
Genetic Code, triplet code, Genetic variations and Mutations, incorporation of novel aminoacids,
Translation – initiation, elongation, termination of protein synthesis, components required at each stage, sequence of reaction, inhibitors of protein synthesis, post translational modifications of proteins.

Learning outcome:
Students undergoing training in this unit will understand the beauty of transcription and translation from the genetic material, its regulation and development into a functional protein.

Unit 4:Gene Expression 12 hrs

Regulation of gene expression in prokaryotes and virus, Bacterial and Viral Genetics, constitutive and inducible enzymes in bacteria, induction and repression
Operon model- Lac operon - Tryptophan operon- arabinose operon. Regulatory RNA gene silencing, RNAi, microRNAs, Types of vectors, regulation of gene expression in bacteriophage.
Regulation of gene expression in eukaryotes, interaction with RNA, DNA binding proteins, gene dosage, gene amplification, regulatory transcription factors, Histones acetylation and deacetylation, epigenetic effects.
Transport and targeting of RNA, Post-transcriptional gene silencing,

Translational control and targeting of protein
Mechanism of steroid hormone and stress induced gene expressions.

Learning outcome:
After the completion of this unit, Students will be able to understand and differentiate the gene regulation in prokaryotes, viruses and eukaryotic cell and will be able to explain the roles of repressors in negative gene regulation and that of activators and inducers in positive gene regulation. In addition they are expected to understand post transcriptional and translational modifications and epigenetic regulations.

Unit 5:Cell signalling 10 hrs

Introduction to cell signaling, types of signaling, types of receptors, other function,
G protein coupled receptros: Heterotrimeric G protein,
Second messengers cAMP, lipid derived second messengers, calcium signaling, Receptor tyrosine kinase (RKT): insulin receptors, General RTK's, Ras and the MAP kinase cascade
Integrin signaling and apoptosis, Relationship between signaling pathways.

Learning outcome:
Students undergoing training on this unit will be able to understand the structure of the cells, in relation to, the localization of the receptors, and modulation of gene expression via transmission of signal from the receptor to the intracellular regions.

Recommended books for reference:

1. B. Alberts A. Johnson, J.Lewis, M. Raff, K.Roberts, and P. Walter, Molecular biology of cell, 2008, Garland Science, Taylor & Francis Group.
2. P. J. Russell, P.E. Hertz, C. Starr, S. L. Wolfe and B. McMillan, Cell and Molecular Biology, 1st edition 2009 Cengage Learning.
3. K. Wilson & J. Walker., Principle & Techniques of Practical Biochemistry and Molecular Biology, 2006, Cambridge University Press.
4. D. Friefielder, Physical Biochemistry: Applications to Biochemistry and Molecular Biology, 1982 W. H. Freeman.
5. Walt Ream Katharine G. Field. Molecular Biology Techniques: An Intensive Laboratory Course. Academic Press (November 26, 1998)
6. T. A. Brown, Essential Molecular Biology: A Practical Approach, Oxford University Press (October 05, 2000)
7. T. A Brown, Genomes, 2nd edition. UK. Oxford: Wiley-Liss; 2002. ISBN-10: 0-471-25046-5
8. Benjamin Lewin, 'Lewin's Gene' XI, Jones & Bartlett Publishers, 2014
9. Lodish, Molecular Cell Biology VIII Edition, Macmillan Learning, 2016, ISBN-10: 1-4641-8339-2; ISBN-13: 978-1-4641-8339-3
10. James D. Watson, Molecular Biology of the Gene, Seventh Edition, Harvard University/ Pearson Publishing, 2013
11. Molecular Cloning: A Laboratory Manual - Joseph Sambrook, Cold Spring Harbour Laboratory Press

Course Name: MICROBIOLOGY
Course code: APBS103
Credits: 4 (56 hours)

Course Objectives:

- To provide an overview on different groups of microorganisms and their systematics, nutritional requirement, culturing techniques and molecular aspects.
- To train in the utilization of beneficial microorganisms for agriculture, pharmaceutical and biotechnological industries.
- The significance of microorganisms in health and disease of plant, animal and humans.

Unit 1: Introduction 10 hrs

History and scope of microbiology, discovery of micro organisms, Theory of spontaneous generation, germ theory of diseases, contributions of Antony van Leeuwenhock, Louis Pasteur, Robert Koch, Edward Jenner, Winogradsky, Beijerink, Alexander Flemming and others. Ultra structure of prokaryotic cell, Cell wall organization on Prokaryotes, Eukaryotes and Archaea. Different group's microorganism: general characters, reproduction, life cycles of Bacteria, fungi, protozoa, virus, mycoplasma.

Learning outcome:
Student will acquire the knowledge on the History and applications of microbiology, understand the evolution of microbiology as a science, know the contributions of eminent microbiologist and understand the structure of major groups f microorganisms

Unit 2: Growth, Nutrition and Methods of studying microorganisms 12 hrs

Physical and chemical methods of sterilization, Nutritional classification of microorganisms, Types of culture media, Microbial culture techniques, Method of identification, Preservation and Maintenance of microbial cultures, Microbial growth kinetics, Batch and continuous cultures, Measurement of microscopic objects. Principles and working of different types of microscopes (light and electron) and their applications, Biological safety cabinets, Autoclave, Hot air oven, incubator and other important equipments used in standard microbiology laboratory.

Learning outcome:
Students shall be trained the various methods of sterilisation in for microbial decontamination techniques, instruments and methods commonly required for culturing and identification of different groups of microorganisms, tools/instruments common to microbiology. They can professionally apply and evaluate microbiological tests to isolate, characterise, and identify various microorganisms from different sources with wide applications.

Unit 3: Microbial metabolism and Genetics 12 hrs

Metabolic diversity of microbes: Classification and types of microbial metabolism. Introduction to Microbial metabolism, Metabolic Cycles: Aerobic (Glycolysis, The Krebs Cycle, Electron Transport and Oxidative Phosphorylation) and Anaerobic respiration (Fermentation). Alternative metabolic pathways in microorganisms. Microbial Genomes and extra-chromosomal elements (Plasmids and transposons), Gene Regulation, Microbial DNA Replication, Mutation. Mechanisms of Gene Transfer: Transformation, Transduction, Conjugation, Evolutionary, significance of gene transfer.

Learning outcome:
Students shall be able to understand the physiology and biochemistry of various microorganisms, including the genetics of metabolic regulation and also their metabolic diversity. To understand the diversity of microbial world and habitats thereof. The various methods of gene Transfer in bacteria and its genetics, Describe in detail the underlying principles of bacterial genetics relating to gene manipulation/cloning, drug resistance, stain improvement etc. Describe the causes and consequences of mutations on microbial evolution and the generation of diversity.

Unit 4: Microbial Taxonomy 12 hrs

Systematic position of microorganisams in the living world, Principles of bacterial taxonomy and classification, Nomenclature rules, taxonomic ranks. Major characteristics used in identification: morphological, physiological, biochemical, ecological, genetic and molecular. Numerical taxonomy. Historical account of bacterial classification, detailed account of bacterial classification according to the Bergey's Manual of Systematic Bacteriology.

Learning outcome:
To understand the diversity of microorganisms and their Systematic position of microorganisms and master the skill in their identification and their taxonomy and classification

Unit 5: Beneficial and Harmful Effects of Microbes 10 hrs

(i) Role of microbes in Agriculture: Nitrogen-fixing bacteria, Mycorrihiza, Biocontrol agents, Biofertilizers, (ii) Role of microbes in Food and Industry: Fermentation processes, Major industrial products from microbes: Beverages, Secondary metabolites, Recombinant products, (iii) Role of microbes in Environment problems: Waste water treatment, Pesticide degradation, Oil spill treatment etc. Microbes in Extreme environments: Physiological adaptations, enzyme activities and their biotechnological applications. Important Human, Animal and Plant diseases caused Microbes.

Learning outcome:
Student should able to critically evaluate the role of microorganisms in specific biotechnological processes and demonstrate a clear understanding of how biochemical pathways relate to biotechnological applications and the formation of economically important product. Demonstrate a comprehensive knowledge and understanding of medically important microorganisms and their relationship to disease, diagnosis and treatment.

Recommended books for reference:

1. Prescott, L.M., J.P Harley, D. AKlein, 2007 Microbiology VII Ed. Mc Grow Hill,
2. Madigan,MT, JM Mrtinko and J.Parker 2000 Brock Biology of Microbiology IX Ed. Prentice Hall International, Inc.
3. Pelczar Jr, M.J.Chan, E.C.S and Krei N.R (1993) Microbiology McGraw Hill New York
4. Microbiology: An Introduction by Gerard J Tortora, Berdell R Funke, Christine L Case Benjamin-Cummings Publishing Company ; 2008.
5. The Fungi: An Advanced treatise I-IV volumes (Ed) Ainsworth & Sussman; Academic Press.
6. Bacterial Systematics, by Logan, A., Niall A. Logan, Wiley-blackwell; 1994
7. Microbial Physiology by Albert G. Moat and John W. Foster. Third edition, John Wiley and Sons; 2002
8. Microbial Ecology By Atlas R.M., Bartha R., Benjamin Cummings Publishing Co, Redwood City, CA.,1993.
9. Environmental Microbiology by R. Mitchel (2nd edition), Wiley-Blackwell, 2009.
10. Plant pathology by George N. Agrios: 4th ed., Academic press, New York, 1969.
11. Biotechnology: A Text Book of Industrial Microbiology by W. Crueger & A. Crueger, Panima Publishing Corporation, New Delhi/Bangalore, 2000.
12. Fermentation Microbiology and Biotechnology by El Mansi & Bryce, Taylor & Francis, London, Philadelphia, 1999.
13. Principles of Fermentation Technology by P.F. Stanbury, W. Whitaker &S.J. Hall, Aditya Books (P) Ltd., New Delhi, 1997.
14. Modern Industrial Microbiology & Biotechnology by N. Okafer, Scientific Publishers, Enfield, USA., 2007.
15. Food Microbiology: Fundamentals and Frontiers, 2nd edition by Michael P. Doyle, Larry R. Beuchat, Thomas J. Montville, ASM press, 2001.
16. Molecular Genetics of Bacteria by Larry Snyder and Wendy Champness, 3rd edition; ASM press; 2007.

Course Name: GENETICS

Course Code: APBS104a

Credits: 4 (56 hours)

Course Objectives:

The students shall be able to

- Understand model systems for genetic studies. Learn about mutations & chromosomal aberrations.
- Learn Human molecular genetics, tools and work on animal & cell culture models
- Learn about the Genetics of diseases, mapping method, linkage analysis and cytogenetics.
- Learn about the Genetic variation, allele, genetic drift, and quantitative genetics.
- Students would experience Medical genetics and get exposure to Diagnostics genetics.

Unit1: Transmission Genetics 10 hrs

Model systems in Genetic Analysis (Bacteriophage, E. coli, Neurospora crassa, yeast, Arabidopsis, maize, Drosophila, C. elegans, Zebra fish, mouse, Homo sapiens-general outline of life cycle, importance in Genetic analysis), Laws of inheritance,
Allelic and non-allelic interactions, Sex-linked inheritance, Quantitative inheritance, Cytoplasmic inheritance, Linkage, Mutation (Classification, mechanism, repair, role in genetic analysis and evolution) Changes in Chromosome number and structure (Polyploidy, aneuploidy, chromosomal rearrangements - deletion, duplication, inversion, and translocation. Meiotic consequences in structural heterozygotes, role in speciation and evolution. Properties and evolution of genetic material, flow of genetic information.

Learning outcome:

Students should be able to tell about the common genetic model systems used for research. They should be aware of the genetic modes of inheritance. They should understand the different types of mutations and link them to genetic instability. They would also be thorough with chromosomal aberrations.

Unit 2: Molecular and Human Genetics 12 hrs

Introduction to Human Genetics (History; Early perception, development and documentation; Genome organization; Chromosome structure, function and implications for disease), Study tools in Human Genetics: Pedigree analysis- Mendelian inheritance and exceptions; Chromosomal analysis (in vitro, in vivo), Biochemical analysis; Somatic cell genetics (somatic cell hybrids, monochromosome hybrid panels, gene mapping); Molecular genetic analysis. Human genome analysis: Conception, mapping, cloning and sequencing, Outcome-Generation of 'OMICS' era, significant leads. Functional genomics and animal models in human disease: An overview; cDNA/gene cloning; site-directed mutagenesis; mammalian tissue culture; cell line transfections; functional assays; Use of model organisms, methods for generation of transgenic animals/ knock-in, knockout models (microinjection, ES cell transformation); ENumutagenesis; RNAi approach; Some examples.

Learning outcome:

Student would learn about the human genome in details, tools used to analysis of the human genome. In addition students will learn about some functional assays on cell lines and look into outcomes through cell culture experiments.

Unit 3: Genetic Diseases 12 hrs

Human genome mapping methods: Physical mapping: Introduction to physical map markers- Chromosomal, G/Q- banding, radiation hybrid, Fluorescence in situ hybridization, comparative genome hybridization, long range restriction mapping, high resolution mapping STS/EST/MS/SNP/sequencing;

Genetic mapping: Linkage analysis (RFLP/MS/SNP); Applications of mapping in normal and disease genome analysis: Gene identification using positional and functional cloning approach,

Common syndromes due to numerical chromosome changes, Common syndromes due to structural alterations (translocations, duplications, deletions, microdeletion, fragile sites). Genetic variation in health and disease:

Human genetic diversity- Methods of study –Biochemical/molecular genetic markers; some examples. Tracing human migrations with autosomal, Y-chromosomal and mitochondrial markers.

Diseases and disorders: Chromosomal disorders: Structural and numerical; Autosomal/sex chromosomal/sex reversal; Mechanisms – mitotic/meiotic non-disjunction/ chromosomal rearrangements; Some examples (Syndromes/Cancer/Infertility); Single gene and disease: Inborn errors of metabolism, Haemoglobinopathies;

Multifactorial disorders: Introduction; Methods of study (Epidemiological, Twin/ adoption and Family studies); Etiology - genetic and non-genetic determinants; Common examples. Epigenetics and disease: Mechanisms (Imprinting/methylation; chromatin remodeling); Current understanding; examples. Mitochondrial myopathies.

Learning outcome:

Students would learn about human genome mapping methods, linkage analysis, cytogenetics, common syndromes, understand genetics single and multifactorial, etiology and epigenetics of disease.

Unit4: Population Genetics 12 hrs

Variation at the genetic level: DNA markers -VNTR, STR, microsatellite, SNP and their detection techniques - RFLP, genotyping, RAPD, AFLP etc.
Organization and measure of genetic variation: Random mating population, Hardy-Weinberg principle, complications of dominance, special cases of random mating – multiple alleles, different frequencies between sexes (autosomal and X-linked). Linkage and linkage disequilibrium.
Sources responsible for changes in gene frequencies: Mutation, selection, migration and isolation; random genetic drift; insights into human migration, natural selection and evolution.
Population substructure: Hierarchical population, isolate breaking, Inbreeding, Assortative mating.
Quantitative Genetics: Johannsen pure-line theory, multiple factor hypotheses, type of quantitative traits, components of phenotypic variation and genetic models for quantitative traits, concept of heritability, artificial selection and realized heritability.

Learning outcome:

Students would learn about the genetic variation, allele, genetic drift, quantitative genetics, population structure. Students would appreciate the principle behind genetic variation, practically look into RFLP.

Unit5: Medical Genomics 10 hrs

Identification and Isolation of disease genes: Single gene disorders- conventional and contemporary methods: Pedigree analysis, Linkage mapping, Positional/structural and functional cloning;
Characterisation; Mutation detection, diagnosis and therapy (with examples from autosomal dominant, autosomal recessive, X-linked dominant, X-linked recessive and complex disease conditions);
Multifactorial disorders: Familial forms- Linkage analysis, Candidate gene identification; Genetic polymorphism and disease susceptibility; Sporadic cases- Association studies- markers from candidate gene/pathways; whole genome association (Single nucleotide polymorphism, CNVs);
Statistical methods used; Pharmacogenetics: History, Early evidence; Clinical determinants; Molecular insights (genes involved in pharmacokinetics and pharmaco dynamics of drugs); Applications in pre-prescription testing.
Diagnostic genetics: Cytogenetics/ Molecular Cytogenetics/Biochemical/Molecular methods; Screening for mutation/ chromosomal anomaly - Adult/Prenatal/Newborn screening; Preimplatation screening (Assisted reproductive technology- in vitro fertilization and Embryo transfer);
Forensic testing - DNA fingerprinting, paternity testing, individual identification.
Treatment of genetic disorders: Methods of therapy - Drug (recombinant proteins); Diet; Gene (Viral vectors, delivery methods, efficacy); Some examples (Thalassemia, Phenylketonuria, Cystic fibrosis, DMD etc).

Learning outcome:

Students would learn about Medical genetics, genetic identification, linkage analysis, pharmacogenetics. They will learn about different genetic diseases and current treatment. They will understand the tools being used for diagnostic genetics for disease identifications. They will be taught gene therapy and the latest techniques used worldwide on gene editing.

Recommended books for reference:

1. Atherly. The Science of Genetics Saunders Publications. 1999.
2. Brooker Genetics – Analysis and Principles Benjamin/Cumings Publications, 1999.
3. Snustad Principles of Genetics. Wiley and sons Publications, 1998
4. Hartl & Jones. Genetics : Principles and Analysis Jones and Bartlett Publications, 1998.
5. Pasternak. An Introduction to Molecular Human Genetics Fritzgerald Publications, 2000.
6. Connor & Smith. Essentials of Medical Genetics Blackwell Editions, 1993.
7. Davies Human Genetic Disease Analysis IRL Publications. 1993
8. Strachan & Read Human Molecular Genetics Wiley1999
9. Obe & Natarajan. Chromosome aberrations - Basic and Applied Aspects. Springer Publications, 1990.
10. Meesfeld Applied Molecular Genetics Wiley-Liss Publications, 1999.
11. Hartl & Clark. Principles of Population Genetics Sinaur Edition, 1997.
12. Smith Evolutionary Genetics Oxford Publications 1998.

13. Hoelzel. 1998. Molecular Genetic Analysis of Populations Oxford University edition.
14. Rimoin. 2002. Principles & Practice of Medical Genetics, Vol I-III Churchill Edition,
15. Trends in Genetics Genetic Nomenclature Guide Elsevier, 1998.

Course Name: GENOMICS and EPIGENETICS
Course Code: APBS104b
Credits: 4 (56 hours)

Course Objectives:
At the end of the course the student will be able to

- Understand the basics of genes structure, gene mappings and importance of molecular markers in diseases.
- To learn the basics of sequencing and genomic technologies.
- To know basics and importance of next generation sequencing and its technologies.
- Shall have a practical training in analysis of next generation sequencing data.
- Shall have an overview of gene regulation and epigenetics.

Unit 1: Genes and Genomes 10 hrs

Gene- Eukaryotic and prokaryotic gene structure, genome databases, Coding regions (genes) and Non-coding regions (Intergenic sequences); Gene and related sequences – NTS, ETS and ITS, 3' UTR, 5' UTR,
Pseudogenes; Repeat sequences: a) Interspersed repeats: LINES, SINES, LTR elements; SINES types: ALU elements, MIR, MIR3; b) Tandem repeats: Transposons; c) Microsatellites; Genetic mapping; Physical mapping (Contig maps, Restriction maps, DNA sequence maps, FISH); Molecular markers for genome analysis-Restriction enzyme sites, EST, STS, microsatellites

Learning outcome:
Students will be able to understand the basic concepts of a gene and genomes. They will be able to differentiate between eukaryotic and prokaryotic gene structures. They will be acquainted to different genome databases and understand their advantages. Conceptualize the importance of repeat sequences in normal and disease conditions. They will conceive the essence of gene mapping and types and the molecular markers necessary for genome analysis.

Unit 2: Genomics 10 hrs

Sanger sequencing-principle, methodology and applications, History of genome sequencing, Human Genome sequencing project; Analysis of gene expression- qPCR, northern blot, southern blot; Transcriptome profiling; DNA microarrays;

Copy number variation, sequence repeats, SNV, haplotype, and their relevance in diseases. Comparative genomics. Metagenomics

Learning outcome:
Students will learn the history and basic principles about sequencing and its applications. Understand the importance of Human Genome Sequencing Project. Different methods of assessing the gene expression at DNA and RNA levels (such as southern blot, northern blot, qPCRs). Conceptualize and differentiate between the global gene expression profiling methods. Understand the relevance of copy number variations, sequence repeats, haplotypes and their importance in diseases. Perceive the importance of comparative and Metagenomics.

Unit 3: Next Generation Sequencing (NGS) technology 14 hrs

Brief history and applications-Whole genome - de novo sequencing or resequencing; exome sequencing; RNA sequencing; small RNA sequencing; metagenomics; NGS workflow: DNA/RNA isolation and quantitation; Fragmentation (different methods – Physical / Enzymatic/ Chemical);

Library preparation-blunt end and adapter ligation, amplification, index addition; single end and paired end reads; Exome/ gene panel capture; Ribosomal RNA depletion (RNA-Seq) and small RNA enrichment; 16S rRNA based sequencing for metgenomics; Platforms for NGS sequencing; Clonal amplification- Bead-based or Emulsion-based PCR amplification, array-based or bridge amplification; Sequencing technologies-(Clone-by-clone sequencing, Shot-gun sequencing, sequencing by hybridization and sequencing by synthesis), Emerging sequencing platforms- PacBio (SMRT technology), Oxford Nanopore systems

Learning outcome:
The students will understand the principles and applications of next generation sequencing and different types of sequencing approaches (such as exome/RNA/RNA/small RNA sequencings). They will be able to interpret the sample preparation methods for each sequencing technology. They will perceive and recognize the similarities and dissimilarities in different sequencing technologies and their respective applications.

Unit 4: NGS data analysis 12 hrs

Next generation sequence analyses, Data format, Quality control-Phred score; FastQC and FastX tool kits, data analysis tools and pipeline, Read length, read depth, sequence coverage, Homology, clustering, and phylogeny, Genome alignment and analysis tools- BWA (Burrows-Wheeler Aligner), SAM tools, GATK (The Genome Analysis Toolkit), IGV (Integrative Genomics Viewer), HISAT, StringTie, Cuffcompare, Velvet, Oases, Trinity

Learning outcome:
Students undergoing training on this unit will be able to understand the different types of modifications like methylation and acetylation in relation to DNA, RNA and chromatin remodeling. They will understand the epigenetic modifications leading to alternate splicing and differential expression. They will conceptualize the difference between epigenetic modification and post translational modifications. They will understand the modulation of

gene expression due to modifications like phosphorylation, methylation, acetylation, ligation and ubiquitination. They will also learn the correlation of epigenetic and post-translational modification with different diseases.

Unit 5: Gene expression and Epigenetics 10 hrs

RNA-seq analyses. Differential expression, stochasticity, and FDR. Alternate splicing, ENCODE. Epigenetic modifications and gene expression: DNA methylation, Histone modifications, non-coding RNA. Linking epigenetic modifications to chromatin remodelling and transcription. Epigenomic analyses and cancer/ diseases. Bisulfite sequencing.

Learning outcome:
Students undergoing training on this unit will be able to understand the different types of modifications like methylation and acetylation in relation to DNA, RNA and chromatin remodeling. They will understand the epigenetic modifications leading to alternate splicing and differential expression. They will conceptualize the difference between epigenetic modification and post translational modifications. They will understand the modulation of gene expression due to modifications like phosphorylation, methylation, acetylation, ligation and ubiquitination. They will also learn the correlation of epigenetic and post-translational modification with different diseases.

Recommended books for reference:

1. Bioinformatics - From Genomes to Drugs (2001) Thomas Langauer (editor) Wiley-VCH; 1st edition
2. Bioinformatics-Sequence and Genome Analysis (2004) David W Mount Cold Spring Harbour Laboratory Press; 2nd edition
3. Broad-based Proteomics strategies: a practical guide to proteomics and functional screening David R M Graham et al J.Physiol 2005, 563.1, 1-9
4. Comparative Genomics Webb Miller et al Annu.Rev.Genomics Hum.Genet 2004, 5, 15-56
5. Discovering genomics, Proteomics and Bioinformatics (2006) A. Malcoln Campbell, laurie J. Heyer Benjamin Cummings; 2nd edition
6. DNA microarrays and gene expression (2002) P Baldi and G W Hatfield Cambridge University Press.
7. Epigenetics: A reference manual. (2011) Jeffrey M. Craig and Nicholas C. Wong, Publishers- Caister Academic Press.

PRACTICAL PAPERS

Course Name: BIOCHEMISTRY
Course code: APBS105
Credits: 2 (56 hours)

SL. No	Laboratory Exercises:	Hours
A.	Qualitative Experiments	
1	Reactions of carbohydrates, proteins and lipids	8
2	Reactions of non-protein nitrogenous (NPN) substances	4
3	Identification of substances of physiological importance	4
4	Qualitative analysis of normal urine	4
5	Analysis of urine for abnormal constituents	4
B.	Quantitative experiments	
1	Estimation of blood sugar and blood urea	4
2	Estimation of serum inorganic phosphate, total serum protein and albumin	4
3	Estimation of urine creatinine	4
4	Paper chromatography	4
5	Glucose tolerance test	4
5	Fractionation of total lipid (glycolipid, neutral lipid and phospholipid) by column chromatography	4
6	Determination of enzyme activity: malate dehydrogenase and catalase activities	4
7	Study of enzyme kinetics, K_m and V_{max} for enzyme	4

Course Name: CELL AND MOLECULAR BIOLOGY
Course Code: APBS106
Credits: 2 (56 hours)

SL. No	Laboratory Exercises:	Hours
1	Microscopy: Parts of phase contrast microscope and its maintenance.	4
2	Study the cells under phase contrast microscope.	4
3	Density gradient separation of human blood cells.	4
4	Different staining techniques for cells DAPI Staining and Giensa staining, staining of actin/microtublues	8

5	Isolation of DNA from cultured cells and its quantification	4
6	Isolation of RNA from cultured cells and quantification	8
7	Agarose Gel Electrophoresis for the separation of DNA	8
8	Design of primers and PCR analysis	8
9	Southern, and Northern Blotting	8

Course Name: MICROBIOLOGY
Course code: APBS107
Credits: 2 (56 hours)

SL. No	Laboratory Exercises:	Hours
1	Safety and occupational Health in a Microbiology Laboratory; Principles of safety; safety cabinets – use and maintenance; incident report and action	4
2	Isolation and cultivation of microorganisms: A) Serial dilution, spread and pour plate methods B) Mixed culture and pure cultures	4
3	Isolation and culturing from soil/water/food and other samples A) Bacteria, B) Fungi (yeasts and molds	4
4	Staining techniques for bacteria – Simple, differential and special staining.	4
5	Laboratory identification of bacteria of clinical importance:: Gram positive cocci; Gram negative cocci; Gram positive bacilli	4
6	Antibiotic sensitivity and MIC testing Kirby-Bauer Disc diffusion method Broth micro-dilution test for MIC	8
7	Evaluation of bacterial growth in liquid media: Sigmoid curve and Diauxic growth curve	4
8	Anaerobic culture techniques	4
9	Isolation and identification of fungi of clinical importance; antifungal agents and their mode of action	4
	Culturing of fungi of industrial importance and downstream processing of the metabolite	8
10	Molecular taxonomy: Extraction of genomic DNA and plasmids PCR based identification	8

Course Name: GENETICS
Course Code: APBS108a
Credits: 2 (56 hours)

SL. No	Laboratory Exercises:	Hours
1	Study of mitosis and meiosis	4
2	Cytogenetics – study of chromosomes, sex chromatin in somatic cells, barr body analysis in cheek epithelium.	4
3	Metaphase preparation and Karyotyping.	8
4	Genetic model organism: Budding yeast (Saccharomyces cerevisiae) Life cycle, genetic experiments, crossing over, segregation of genes through tetrad.	4
5	Generation of mutations by insertion and deletion in yeast.	8
6	Mendelian genetics: monohybridism, Dihybridism and Polyhybridism.	4
7	Determining the segregation of trait through Chi Square Test (use in genetics).	4
8	Branching methods: determining the segregation of traits through Punnett Square.	4
9	Analyzing the segregation pattern of polymorphic genes and gene interactions	4
10	Inheritance: sex linked, genetic linkage	4
11	Population genetics: determining allele frequency, genotype frequency, Hardy-Weinberg equilibrium with two or multiple alleles.	4
12	Quantitative genetics: Analyzing the inheritance of quantitative traits.	4

Course Name: GENOMICS AND EPIGENETICS
Course Code: APBS108b
Credits: 2 (56 hours)

SL. No	Laboratory Exercises:	Hours
1	Prediction of functional elements in genome sequences: promoters, genes, transcription terminators, transcription factor binding sites, cis-regulatory modules, splice sites , enhancers and micro-RNAs	8
2	Comparative genomics and Prediction of interaction networks: orthologs, cluster of orthologous groups, interologs, regulons, operons, gene-neighbors, conservation of gene-order, gene-fusion, phylogenetic profiles, co-evolution, domain-domain interactions and	8

	co-expression networks	
3	Next generation sequence analyses: Data format, Quality control-Phred score	8
4	FastQC and FastX tool kits,	8
5	Data analysis tools and pipeline, Read length, read depth, sequence coverage, Homology, clustering, and phylogeny,	8
6	Genome alignment and analysis tools: BWA (Burrows-Wheeler Aligner), SAM tools, GATK(The Genome Analysis Toolkit) IGV (Integrative Genomics Viewer) HISAT String Tie Cuff compare	8
7	Genome and transcriptomics Assembly - Velvet, Oases, Trinity	8

SEMESTER-II Scheme and Courses

Course code	Type of Course	Course name	Hrs/ Week	Credits
APBS201	Open Elective	Environment and Health	3	3
APBS202	Core -Theory	Nanobiotechnology	4	4
APBS203	Core - Theory	Stem cell and Developmental Biology	4	4
APBS204	Core- Theory	Immunology	4	4
APBS 205	Core- Theory	Toxicology	3	3
APBS206	Core -Practical	Nanobiotechnology and Toxicology	4	2
APBS207	Core -Practical	Stem Cell and Developmental Biology	4	2
APBS208	Core - Practical	Immunology	4	2
Total				24

Course Name: ENVIRONMENT AND HEALTH
Course Code: APBS201 (Open elective)
Credits: 3 (42 hours)

Course Objectives:

- To discuss the history and definition of environmental health.
- To discuss the association between population growth and dissemination of environmental pollutants.
- To describe methods used in epidemiology and toxicology to assess environmental exposures and hazards.
- To describe policies that have been developed to manage health risks associated with exposures to environmental hazards.
- To identify chemical, physical, and microbial agents that originate in the environment and can impact human health.
- To connect the gap between environment and public health.

Unit-I: Fundamentals of Environmental Health 12 hrs

Global environmental change: an introduction, Health Risks of Biodiversity loss, Human impact on environment, Basic concept in Environmental Toxicology, Environmental pollution; solid waste and hazardous waste, Biogeochemical cycle and Health impacts, Environment-human interaction: Important environmental toxicants: Pesticides, Heavy metals, Organic pollutants, Endocrine disruptor, Carcinogenesis, mutagenesis and genotoxicity, Ionizing and Nonionizing Radiation. Environmental and biological indicators, Natural resources, conservation and sustainable development.

Learning outcome:
Student will know the fundamental aspects of environmental health and shall able to describe methods used in epidemiology and toxicology to assess environmental exposures and hazards.

Unit-II: Air pollution and health 10 hrs

Chemical composition of Air: Classification of elements, chemical speciation, Particles, ions and radicals in the atmosphere, Impact of air quality, aeroallergens and degraded air quality, respiratory diseases, Thermochemical and photochemical reactions in the atmosphere. Global warming and climate change, Stratospheric ozone depletion and Public Health, Oxygen and ozone chemistry. Chemistry of air pollutants, Photochemical smog. Air pollution, Climate change epidemiology: Problems and Challenges, Health exposures: weather, climate variability, Indoor and outdoor air pollution: Thermal extremes and their health impacts.

Learning outcome:
Student shall able to demonstrate the various forms of air pollution and its impact on human health. They also know the major health issues concerned with air pollution such as asthma, COPD etc.

Unit-III: Water pollution and health 10 hrs

Types, sources and consequences of water pollution. Physico-chemical and Bacteriological sampling and analysis of water quality. Water quality standards. Natural and anthropogenic sources of pollution, Primary and Secondary pollutants, Transport and diffusion of pollutants, Environmental Epidemiology, Infectious diseases: Climate and Its Impacts on Vector-Borne and Zoonotic Diseases, Food security: Challenges of Climate Change to Food Security, Safety, and Nutrition, Food- and water-borne diseases. Sources of marine pollution and control. Criteria employed for disposal of pollutants in marine system–coastal management. Biotechnological approaches and steps involved in conventional and advanced water treatment technology.

Learning outcome:
Student shall able to demonstrate the various sources for water pollution and its impact on human health including infectious disease transmitted through drinking water. They also will know the major water purification methods employed for safe water.

Unit-IV: Land pollution and health 10 hrs

Physico-chemical and bacteriological assessment of soil quality, Soil pollution, Industrial waste effluents and heavy metals, their interactions with soil components, Soil Pollution Control. Different kinds of synthetic fertilizers and their interactions with different components of soil. Effects of mercury, lead, chromium, cadmium, arsenic and nitrate on human health. Radioactive and Thermal Pollution. Involvement of microbial communities in bio-degradation of different insecticides, fungicides and weedicides in soil. Microbiological

management of hazardous waste and wastelands. Environmental laws and regulations, Environmental management and sanitation, Biosafety: Epidemic and pandemic, WHO Biosafety Manual, Management of Biosafety in Laboratories and Biomedical Facilities, Swachh bharat initiative.

Learning outcome:
Student shall be able to enumerate the different sources of land pollution and its consequences on human health. They shall also know the various methods of waste segregation, disposal and biosaferty measures.

Recommended books for reference

1. Koren H, Bisesi MS. Handbook of Environmental Health. 2011. 4th Edition CRC Press
2. Spellman FR, Bieber RM. Environmental Health and Science Desk Reference. 2012. The Scarecrow Press, INC
3. Robert Friis. Essentials of environmental health. 2007. Jones and Bartlett Publishers
4. Howard Frumkin . Environmental Health: From Global to Local. 2016. 3rd edition, John Wiley & Sons
5. Koren H. Handbook of environmental health and safety: principles and practices. 1980. Pergamon Press Inc., New York.
6. Battersby S. Clay's handbook of environmental health. 2016. Routledge

COURSE NAME: NANOBIOTECHNOLOGY
Course Code: APBS202
Credits: 4 (56 hours)

Course Objectives:

At the end of the course the student will be able to

- Know the fundamentals of Nanomaterials
- Understand about polymeric macromolecules.
- Understand about the synthesis of functional polymers through living polymerization
- Familiarize different techniques involved in characterization

Unit 1: Introduction to nanomaterials 12 hrs

Nanotechnology-introduction and history, biomimetics, nanoparticles, nanowires, thin films and multilayers, applications in physical chemical materials, nanobiotechnology, biomolecules as nanostructures and applications in nanotechnology. Synthesis of nanomaterials, nanocomposites, nanoengineered thin films, hydrogels and other nanomaterials, Physical methods, mechanical, based on evaporation; sputter deposition, chemical vapour deposition (CVD), and electric arc deposition. Chemical methods, synthesis

of nanoparticles by colloidal route, microemulsion, sol-gel method, chemical precipitation and pyrolysis. Biological methods-synthesis using microorganism, synthesis using plant extracts, use of proteins and template like DNA.

Learning outcome:
Students will have an idea about the fields of nanotechnology

Unit 2:Introduction to macromolecular science 10 hrs
History of macromolecular science and concept of macromolecules; Basic concepts in polymer science, classification, monomer structure and polymerizability, Chemical bonding, methods of polymerizations, concept of functionality, measurement of molecular weight and size, degree of polymerization, molecular weight distribution and Polydispersity

Learning outcome:
After finishing this chapter, student will understand the history and evolution of macromolecular science

Unit 3: Synthesis aspects of macromolecules 12 hrs
Synthesis of structural and functional polymers; addition and condensation polymerizations, controlled "living" radical polymerization methods, nitroxide mediated polymerization (NMP)-atom transfer radical polymerization (ATRP), reversible addition fragmentation chain transfer polymerization (RAFT), ring opening polymerization (ROP), synthesis of polypeptides; copolymerization, mechanisms of copolymerization, copolymer composition, block and graft copolymers.

Learning outcome:

Unit 4:Surface morphological studies 10 hrs
Characterization of bio/polymer nano materials, optical (UV-Vis/Fluorescence), X-ray diffraction, imaging and size (Electron microscopy, Light scattering, Zeta potential), surface and composition (ECSA, EDAX, AFM/STM,TEM, FESEM), spectral analysis of polymers, differential thermal analysis,thermo gravimetric analysis, molecular weight distribution by GPC and lightscattering method.

Learning outcome:
After finishing this chapter, student will understand the recent trends in polymer science.

Unit 5: Applications of nanomaterials 12 hrs
Application of Bio-nanomaterials; magnetic,electrical, electrochemical and imaging; Bio-functionalization of surfaces with peptides, proteins or sub cellular organelles, surface engineering of biomaterials; overview of applications of nanotechnology in biomaterial science, Protein electrochemistry, nanomaterial-cell interaction, manifestation of surface modification, Biodegradable and water soluble polymers, polymer gels, bioresponsive polymers,drug delivery systems, antibacterial/ antifungal/antiviral agents, Biopolymers in medicine, polymer therapeutics.

Learning outcome:
Students will know how to interpret the surface morphological aspects of nanomaterials

Recommended books for reference:

1. Shastri, Venkatram Prasad; Altankov, George; Lendlein, Andreas (Eds.). Advances in Regenerative Medicine: Role of Nanotechnology, and Engineering Principles. 1st Edition., Springer 2010, XIV, 406 p.
2. Harry F. Tibbals. Medical Nanotechnology and Nanomedicine (Perspectives in Nanotechnology). CRC Press; 1 edition (September 29, 2010)
3. Mark A. Ratner and Daniel Ratner, Nanotechnology:A Gentle Introduction to the Next Big Idea, Pearson education Inc., Prentice Hall / PTR, New Jersey , USA (2003).
4. C. N. R. Rao, A. Mu ller, A. K. Cheetham, The Chemistry of Nanomaterials: Synthesis, Properties and Applications, Volume 1, Wiley-VCH, Verlag GmbH, Germany (2004).
5. ZhongweiGu, Bioinspired and Biomimetic Polymer Systems for Drug and Gene Delivery, Chemical Industry Press and Wiley-VCH Verlag GmbH & Co. KGaA (2015).
6. Rob Burgess,Understanding Nanomedicine: An Introductory Textbook, Pan Stanford (CRC Press), 1st edition, Singapore (2012).
7. Nanotechnology; Principals and Practices by Sulabha K. Kulkarni, (2009 Revised edition), Capital Publishing company, New Delhi.
8. Biological Nanostructures and Application of Nanostructures in Biology by Michael A. Stroscio and Mitra Dutta (2004) , Kulwer Academic Publishers,
9. BioNanotechnology, Elisabeth S. Papazoglou, AravindParthasarathy, First Edition (2007), Morgan & Claypool Publishers' series.
10. Bionanotechnology, by David S. Goodsell (2004), John Wiley & Sons, Inc, Publication.
14. Hand book of radical polymerization-Editor(s): Krzysztof Matyjaszewski, Thomas P. Davis- Wiley

Course Name: STEM CELLS AND DEVELOPMENTAL BIOLOGY
Course Code: APBS203
Credits: 4 (56 hours)

Course Objectives:

At the end of the course the student will be able to:

- Appreciate the mammalian developmental biology in the right perspective
- Understand the importance of regenerative stem cells in mammalian development
- Understand the cellular energetics in somatic versus regenerative stem cells
- Understand the similarities and differences between regenerative and cancer stem cells
- Make presentations on developmental biology and patterning of ecto, meso and endoderm
- Take up research areas for PhD work in regenerative and/or cancer stem cells or developmental biology
- Take up an industrial job in the biotech industry working on regenerative stem cell therapeutics for generation of cell therapy products
- Take up entrepreneurship development for start-up on regenerative stem cell therapy products

Unit 1: Introduction, origin of stem cells and types. 12 hrs

Developmental biology-Historical perspective. Mammalian development with special emphasis on mouse and human developmental biology, pre-embryonic development, patterning of vertebrate development, axis and body plans, development of germ layers. Development with special emphasis to neuroectodermal, mesodermal and endodermal specification during pre-embryonic mammalian development. Diversification of gene and protein expression, mechanism of differentiation and cross-talk between various cell lineages during mammalian development. Diversification of potency of stem cells during mammalian development. Concepts of regenerative and cancer stem cells in correlation to development and/or developmental imbalance, pre-and post embryonic.

Learning outcome:
Student shall know the basic concepts of stem cells, developmental biology. Concepts of cancer stem cells and cellular markers for differentiating the cell types

Unit 2: Stem Cell metabolism, Metabolic differences between somatic cells, stem cells and cancer cells, Stem Cell Energetics 10 hrs
Cellular metabolism in mammalian system. ROS generation and management by somatic versus stem cells. Cellular imbalance in relation to oxidative stress in cancer cells, somatic cells and stem cells. Oxidative phosphorylation versus glycolysis, stem cell energetic.

Learning outcome:

Student shall able to distinguish between the metabolism in somatic cell, stem cells and cancer cell metabolism.

Unit 3: Embryonic/pluripotent stem cells, Research using embryonic/pluripotent stem cells, Adult stem cells, Research using adult stem cells 12 hrs

Embryonic stem cells-historical perspective. Induced pluripotent stem cells as groundbreaking discovery. Adult stem cells-historical perspective. Research using embryonic stem cells and its advantages. Research using induced pluripotent stem cells and its advantages. Research using adult stem cells and its advantages.

Learning outcome:

Students shall learn the hall marks of embryonic/pluripotent stem cells and its possible application in tissue engineering and regenerative medicine

Unit 4: Clinical applications and status of clinical research/trials using regenerative stem cells: embryonic/pluripotent and adult stem cells; Regenerative stem cell based cancer therapeutics 10 hrs

Status of research for regenerative applications using regenerative stem cells. Status of pre-clinical and clinical trials using regenerative stem cells. Principles of Cancer therapeutics using regenerative stem cells. Status of pre-clinical and clinical trials for cancer therapeutics using regenerative stem cells.

Learning outcome:

Student shall able to gain knowledge of the current status of clinical using regenerative stem cells with case studies from around the world.

Unit 5: Ethical considerations for the research and clinical use of various kinds of stem cells 12 hrs

Need for ethical considerations for research and clinical use of various kinds of stem cells. Regulatory requirements as per Indian and global standards for carrying out stem cell research. Regulatory requirements for clinical use of stem cells as per Indian and global standards, introduction to c-GMP facility, overview of various stem cell products Safety issues related to various stem cell therapies. Stem cell banking, informed consent and regulatory issues. Stem cell products obtained from pluripotent stem cells, adult stem cells for regenerative applications versus applications for cancer therapeutics-Similarities, differences and ethical considerations

Learning outcome:

Student shall able to understand the importance of Ethical considerations for the research and clinical use of stem cells. They shall also know the various committees regulating the stem cell research to avoid unethical practices.

Recommended books for reference:

1. Stem Cells from a Biological Perspective: What They Are, Where They Are Found, and What Can Be Done with ThemBy Niemi, William DAlbany Law Review, Vol. 65, No. 3, Spring 2002
2. Renewing the Stuff of Life: Stem Cells, Ethics, and Public PolicyBy Cynthia B. Cohen Oxford University Press, 2007

3. Pluripotent Stem Cells - From the Bench to the Clinic, Edited by Minoru Tomizawa ISBN 978-953-51-2472-6, Print ISBN 978-953-51-2471-9, 530 pages, July, 2016
4. Progress in Stem Cell Transplantation, Edited by Taner Demirer, ISBN 978-953-51-2227- 2, 206 pages, December, 2015
5. Adult Stem Cell Niches, Edited by Sabine Wislet-Gendebien, ISBN 978-953-51-1718-6, 328 pages, August, 2014
6. Pluripotent Stem Cell Biology - Advances in Mechanisms, Methods and Models, Edited by Craig S. Atwood and Sivan Vadakkadath Meethal, ISBN 978-953-51-1590-8, 240 pages, July, 2014
7. Pluripotent Stem Cells, Edited by Deepa Bhartiya and Nibedita Lenka ISBN 978-953-51-1192-4, 638 pages, August, 2013
8. Stem Cell Biology in Normal Life and Diseases, Edited by Kamran Alimoghaddam ISBN978-953-51-1107-8, 194 pages, May, 2013
9. Neural Stem Cells - New Perspectives, Edited by Luca Bonfanti ISBN978-953-51-1069-9, April, 2013, 428 pages,
10. Developmental Biology Hardcover –Scott F. Gilbert (Author), Susan R. Singer (Author) Sinauer Associates Inc., U.S.A.8th Revised edition (10 May 2006),750 pages

Course Name: IMMUNOLOGY
Course Code: APBS204
Credits: 4 (56 hours)

Course Objectives:

At the end of the course the student will be able to

- Know the basics concepts used in immunology
- Know the mechanism of immune system and its regulation
- Interpret the importance of immunological response
- Understand the advanced knowledge and application in solving problems related to immunological disorders
- Develop certain diagnostic and therapeutic approaches related to immunological disorders and also he/she will be well acquainted with information related to antibody development.
- Have information about safe working practice in immunology laboratory.

Unit 1: Introduction to Immune system: 10 hrs

Introduction to immune system, Cells, Organs and Tissues of immune system. Types of Immunity - Innate immunity, Acquired immunity, Mechanisms of barrier to entry of microbes/pathogens (Protective and Destructive), Antibodies. Complement system, T Cell Receptors and MHC Molecules

Learning outcome:
Students will learn about various components of immune system and how immune system will activate and response to foreign pathogens . They will know about complement system and MHC molecules

Unit 2: Immune Effecter mechanism: 13 hrs

Hematopoiesis and its regulation, Cytokines in immunity, interferons, interleukins, tumor necrosis factors, Transforming Growth Factor, chemokines and adhesion molecules. Complement system(classical and alternative pathways), cell-mediated effector responses(Cytotoxic T cells, Natural Killer Cells, ADCC, NK cell receptors, inverse correlation with target MHC expression, missing self hypothesis, cytotoxicity reaction), leukocyte activation and migration, phagocytosis and microbicidal mechanisms. Immediate hypersensitivity: role of eosinophils, and mast cells. Asthma. IgE receptor, prostaglandins and leukotrienes. Antibody structure and function (classification of immunoglobulins, immunoglobulin domains, concept of variability, isotypes, allotypes and idiotypic markers), antibody mediated effector functions, antibody classes and biological activities, antigenic determinants on antibody molecules, , monoclonal antibody, immunotoxins, abzymes.

Learning outcome:
Students will familiarize with different types of cell signalling molecules in immunology and gain knowledge related to functions of various immune cells. Students will understand the mechanism of immune system.

Unit 3: Cell mediated immunity 12 hrs

Antigens, antigenicity, and immunogenicity. B and T cell epitopes. Generation, activation and differentiation of B-lymphocyte, Immunoglobulin superfamily, Expression of immunoglobulin genes (Genetic model compatible with immunoglobulin structure, Antibody diversity, VDJ recombination, class switching of Ig).Antigen-Antibody reactions, Major Histocompatibility Complex(genetic organization of H2 and HLA complexes. Class I and class II MHC molecules, structure and function), Differentiation and activation of B cells, BCR and pre BCR, receptor editing, T cell help , T-cell receptor, Antigen processing and presentation and T-cell antigen recognition. T-cell maturation, activation and differentiation, Th1/Th2 cells and cytokines. – Applications in Diagnostics.

Learning outcome:
Students will understand the different aspects of immune response and know about the cellular structure and functionality of different type of immune cells such as T-cells, B-cells etc. They will understand different types of MHC molecules and know about how the antigen is presented and eliminated from the body by activation of immune response

Unit 4: Immune system in health and disease: 11 hrs

Hypersensitivity, Auto immunity and immunodeficiency, molecular mimicry, immune therapy, Tumor and Transplant immunology, Parasitic immunology, Phage display, Animal models and transgenic animals and their use in immunological studies. Routes of Inoculation Transgenic animals, Experimental immunology: Vaccine development (Recombinant,

Combined and polyvalent vaccines) Stem cell technology. Manufacturing of immuno-diagnostics and Clinical Trials.

Learning outcome:
Students will know about what will happen if immune system is defective, gain knowledge on various animal models used for immunological studies and will learn about various therapeutic and diagnostic use of immunology

Unit 5: Immunological Techniques: 10 hrs
Hybridoma, monoclonal antibodies, and antibody engineeringAntibody(mAb, pAb), Chimeric antibodies, Evaluation of immune response by using ELISA, RIA, Western blot, immunoprecipitation, flowcytometry, immunofluorescence, Qualitative, quantitative and kinetic modes of expression: Real-time PCR, Microarray, Immune-seq.

Learning outcome:
Students will learn how to developed antibodies and will familiarize with various immunological techniques

Recommended books for reference:

1. Roitt's Essential Immunology
2. Janeway. Immunobiology: The immune system in health and disease by Charles
3. Kuby. (2013) Immunology, International Edition by Judy Owen, Jenni Punt and
4. Sharon Stranford.
5. William E. Paul. (2012). Fundamentals of Immunology, VII Edition (2012).
6. Relevant review articles/research papers/handouts provided during the course.

Course Name: TOXICOLOGY
Course code: APBS205
Credits: 3 (42 hrs)

Course Objectives:

At the end of the course the student will be able to;

- Describe the basic concepts used in toxicology
- Describe inherent mechanisms of detoxification
- Understand the sources, distribution and accumulation of toxicants
- Describe the methods used for toxicity assessment and available guidelines
- Understand the target organs for some of the common toxicants
- Demonstrate the effect of toxicants on health, environment and methods of monitoring

Unit- 1:Introduction to toxicology 12 hrs

History, introduction, basic principles and scope of toxicology. Dose response relationships LD50, ED50, LC50, EC50. General mechanisms of toxicity. Disposition of toxicants-

adsorption, distribution and elimination of toxicants. Biotransformation of xenobiotics- basic properties, categories and distribution of xenobiotic biotransforming enzymes. Risk Assessment (Hazard Identification, Dose Response Assessment). Determination of harmful effects of chemicals, adverse effects of chemicals, understanding the fate of chemicals. OECD Guidelines for the Testing of Chemicals. Various techniques for toxicity evaluation (in vitro, in vivo, molecular, epidemiological)

Learning Outcome:
Students will be able to learn the basic principles and techniques of toxicity evaluation and will be able to evaluate the fate/detoxification mechanisms of various toxicants and the dose-response relationships

Unit-2:Health effects and indicators of toxic agents 10 hrs

Toxic agents: toxic effects of pesticides and metals with special reference to DTT, lindane, cyclodienes, lead, arsenic, mercury, cadmium, aluminium. Health effects of radiation and radioactive materials. Important radiation episodes. Bioindicators: Overview of bioindicators – theory, practices and problems; biondicators of air, water and soil pollution. Biomonitoring of heavy metals, biomontoring of air pollution around urban and industrial sites; organisms used as indicator of population.

Learning Outcome:
Students will be able to describe common pollutants and their mechanism of action and will learn the deleterious effects of different pollutants on biotic/abiotic components of the environment

Unit-3:Branches of toxicology 10 hrs

Basic principles and specific examples of Hepato and renal toxicology, Reproductive and developmental toxicology, Immunotoxicology, cutaneous and pulmonary hypersensitivity. Persistent Organic Pollutants (POPs) and dioxins. Neurotoxicology, Metal toxicology: mercury, cadmium. Ozone, a criteria for air pollutant. Nanoparticle toxicology. Environmental diseases: Asbestosis, silicosis, synopsis, asthma, fluorosis and allergies, epidemiological issues – Malaria, Kala azar and water borne diseases. Properties and toxicities of animal venoms with special reference to scorpions, spiders, ticks, centipedes, millipedes, ants, bees, wasps, snails, lizards and snakes. Anti-venoms. Toxic effects of plant, fungi and algae.

Learning Outcome:
Students will know the concepts of bioindicators and their significance and will be able to describe the toxic effects of various chemical toxicants and radioactive hazards. They will also be able to understand the biomonitoring methods

Unit-4: Applications in various field 10 hrs

Applications of toxicology: Food toxicology: Introduction, safety standards for food, food ingredients and contaminants. Forensic toxicology: analytic role, toxicologic investigations of poison death, criminal poisoning of the living. Clinical toxicology: strategy for treatment of the poisoned patient. Cosmetic toxicology: introduction. Occupational toxicology: introduction, occupational diseases, worker health surveillance, exposure monitoring.

Learning Outcome:

Students will be able to understand the tissue specific toxicity and mechanisms and will be able to understand the toxicant overexposure symptoms and disorders

Recommended books for reference:

1. Calow.P. 1994. Handbook of Ecotoxicology. Blackwell Scientific Publications, London
2. Chatterji,M., M.Munasinghe and R.Ganguly. 1998. Environment and Health in Developing Countries. A.P.H.Publishing House, New Delhi.
3. Forbes,V.E. and T.L.Forbes. 1994. Ecotoxicology in Theory and Practice. Chapman & Hall, London.
4. Hayes, W.A. 2001. Principles and Methods of Toxicology, CRC, USA.
5. Jacobson-Kram,D. 2006. Toxicological testing handbook: Principles, Applications and Data Interpretation, Taylor and Francis, New York.
6. Klaassen,C.D. and Watkins,J.B. 2003. Essentials of Toxicology, McGraw-Hill Professional, New Delhi
7. Levin, S.A. and M.A. Harwell, J.R.Kelley and K.D. Kemball. 1989. Ecotoxicology: Problems and Approaches. Springer-Verlag, New York.
8. Manahan, S.E. 2000. Environmental Chemistry, Lewis Publishers, New York.
9. Pery, G. 1980. Introduction to Environmental Toxicology, Elsevier, Amsterdam.
10. Walker, C.H., R.M. Sibly, S.P. Hopkin and D.B. Peakall. 2012. Principles of Ecotoxicology, CRC Press, New York.
11. Wright, D.A. and Welbourn, P. 2002. Environmental Toxicology, Cambridge University Press, London.

Syllabus for Practical Papers

Course Name: NANOBIOTECHNOLOGY AND TOXICOLOGY
Course code: APBS206
Credits: 2 (56 hours)

SL. No	Laboratory Exercises:	Hours
1	Fabrication of nanomaterials	4
2	Synthesis of nanoparticles using biological processes	4
3	Detection of nanoparticles in colloidal solutions using UV-vis absorption technique.	4
4	Radical polymerization of functional monomers	4
5	Synthesis of bioresponsive polymers	8
6	Fabrication of bio-nano composites	4
7	Fluorescent nanomaterials for bioimaging	4
8	Cytogenetic evaluation of chromosomal damage (Chromosomal Aberration Test)	8
9	Chemical toxicity: Micronulceus assay	4
10	Toxicity of nano materials	4
11	Estimation of chlorine in drinking water	4
12	OECD guidelines and Safety evaluation	4

Course Name: STEM CELLS AND DEVELOPMENTAL BIOLOGY
Course code: APBS207
Credits: 2 (56 hours)

SL. No	Laboratory Exercises:	Hours
A.	Cell culture experiments	
1	Basic mammalian cell culture-Media preparation	4
2	Thawing and Seeding of cells and Cell passaging	8
3	Cell counting	4
4	Isolation of mouse bone marrow mesenchymal stem cells (MSC)	4
5	Harvesting of tissues, digestion and processing for pre plate culture	8
6	Isolation of adipose stem cells/ muscle stem cells from mouse tissue	8
7	Cancer stem cells	4
B.	Characterization experiments	
8	Analytical flow cytometry for stem cell immunophenotyping in Bone marrow MSC/ Adipose tissue MSC/ muscle stem cells	4
9	Immunofluorescence staining of MSCs	4
10	Fluorescent Assisted Sorting (FACS) of Stem Cells	8

Course Name: IMMUNOLOGY
Course code: APBS208
Credits: 2 (56 hours)

SL. No	Laboratory Exercises:	Hours
1	Immune system and organs in a mammalian animal model	8
2	H & E staining of spleen	4
3	Lymphocyte isolation and staining	4
4	ELISA	8
5	Single Radial immuno-diffusion	4
6	Ouchterlony diffusion on gels	4
7	Counter current immune electrophoresis	4
8	Rocket immunoelectrophoresis	4
9	Latex agglutination kit	4
10	Blood typing	4
11	Immunocytochemistry (Light, Fluorescent Microscopy)	8

SEMESTER-III – Scheme and Courses

Course code	Type of Course	Course name	Hrs/ Week	Credits
APBS301	Open Elective	Scientific Communication	3	3
APBS302	Core -Theory	Biostatistics and Bioinformatics	4	4
APBS303	Core - Theory	Systems biology and Omics Technology	4	4
APBS304	Core -Theory	Genetic Engineering	4	4
APBS305	Core- Theory	Cell culture Techniques	3	3
APBS306	Core -Practical	Biostatistics and Bioinformatics	4	2
APBS307	Core - Practical	Systems Biology and Omics Technology	4	2
APBS 308	Core -Practical	Cell culture techniques	4	2
Total Credits				24

Course Name: SCIENTIFIC COMMUNICATION
Course code: APBS301 (Open elective)
Credits: 3 (42 hours)

Course Objectives

At the end of the course, students shall be able to

- Harness the skills and attitudes, which are relevant to their main courses of study
- Empowered to discover the prospects in scientific research and in career identification
- Develop the innovative skills, improve the personality and communication skills,
- Learn hands-on training, presentations, field trips, and workshops, which will allow the students to understand the basic concept of research.

Unit I: Research Practices and Applications (10 hours)

The review of literature–Approaches to research - How to use the search engines such as PubMed, Scopus, and Science Direct etc.– Planning the research -Development of hypothesis and research ideas–Designing a research work or projects-Selecting methods of data collection - Organizing the research notes and logbooks-Interpretation of results–Ethics and integrity in research - Learning Good Laboratory Practices (GLP).

Learning outcome:

Students will be able to identify the scientific problem and would become capable to troubleshoot on their own to find the solutions.

Unit 2: Effective Writing and Presentation Skills (10 hours)

Writing research and review paper – Documenting the paper – Drafting and revising – Preparing the final draft – How to communicate the manuscript to journals - How to make powerpoint presentation-How to present the scientific findings in front of scientific peers-How to present the oral poster presentation in symposium and conference-Attending the web based webinar, TED talks, podcasts etc.

Learning outcome:

At the end of the presentation course, students will be able to prepare effective PowerPoint presentation, discuss the research finding with scientists, and sharpen their communication skills.

Unit 3: Skill Advancement Programs (10 hours)

Learning and utilization of advanced software such as EndNote, Adobe Photoshop, Origin Lab, Sigma Plot, and Graph Pad Prism etc. – Development of quality figures for publications, research proposals, and presentations-Introduction to Microsoft Offices (Word, Excel and Power Points)-Creative writing and publishing-How to write a research proposal.

Learning outcome:

Student will be able to write the manuscript and draw the figures according to journal specifications. In addition to this, students will be trained to understand the key features of proposal writing according to the funding agency rules and regulations.

Unit IV: Personality and Career Development (12 hours)

Building a motivated research collaboration among the researchers and expertise in the similar research field-Social interaction– Developing self in work and career -Dress code-Management in health, mindfulness and time -How to prepare and attend the interview-How to make resume – Do and Don’ts-Innovation and entrepreneurship-Industrial visits-How to do research based projects-How to develop startup companies.

Learning Outcome:

After this career development course, students will be able to draft resumes and get motivated towards innovations, entrepreneurship, startup companies and product development. Students will have more confidence, motivation and ready to face any problem in their scientific carrier and job opportunity as well as their personal life.

Reference books

1. Bell, Judith, Waters, Stephen. Doing Your Research Project: A Guide for First Time Researchers. McGraw-Hill Open University Press (2014).
2. Victoria E. McMillan. Writing Papers in the Biological Sciences. Bedford St. Martin's Macmillan(2011).
3. Robert Hamper, L. Baugh. Handbook for Writing Proposals, Second Edition-McGraw-Hill (2010).

4. Matt Carter. Designing Science Presentations. A Visual Guide to Figures, Papers, Slides, Posters, and More-Academic Press (2013).
5. Boffito, Daria C. Patience, Gregory S. Patience, Paul A. Communicate Science Papers, Presentations, and Posters Effectively. Academic Press (2015).
6. Paul J. Hartung, Linda M. Subich. Developing Self in Work and Career: Concepts, Cases, and Contexts-American Psychological Association (2010).
7. Alexander Mamishev, Murray Sargent. Creating Research and Scientific Documents Using Microsoft Word-Microsoft Press (2013).
8. Zina O'Leary-The Essential Guide to Doing Your Research Project-SAGE Publications Ltd (2017)
9. Lea Pulkkinen, AvshalomCaspi. Paths to Successful Development: Personality in the Life Course. Cambridge University Press (2002).
10. Kenneth H. Rubin, William M. Bukowski, Brett Laursen. Handbook of Peer Interactions, Relationships, and Groups (Social, Emotional, and Personality Development in Context)-The Guilford Press (2008).
11. David R. Shaffer-Social and Personality Development, Sixth Edition -Wadsworth Publishing (2008).
12. Jule Specht (Eds.). Personality Development Across the Lifespan- Academic Press (2017).

Course Name: BIOSTATISTICS and BIOINFORMATICS

Course code: APBS302
Credits: 4 (56 hours)

Course Objectives:

At the end of the course the student will be able to

- Understand role of Statistics in research
- Scrutinize research data and present data in various forms
- Use descriptive statistics and interpret the results
- Use random sampling methods to collect sample data
- Use inferential statistics- choice of test procedures, analysis and interpretation of data
- Understand bioinformatics and computational biology, and programing in Python and parsing text files
- Understand Needleman-Wunsch and Smith-Waterman algorithm, and run standalone BLAST
- Understand phylogeny trees and use MEGA software
- Understand/parse PDB file, and use VMD for structure visualization

Unit 1: Introduction 8 hrs

Statistics –Definition & scope. Role of statistics in biological /medical research. Data and data types-examples from biological & medical fields. Tabulation of data, frequency tables, bivariate data – cross tabulation. Visualisation of data-different types

of graphs and diagrams, interpretation of diagrams and graphs.

Learning outcome:

Students shall be able to construct and analyze graphical displays to summarize data. They will learn Interpreting and assessing data displayed using visual presentation methods.

Unit 2: Descriptive Statistics 10 hrs

Descriptive statistics – measures of central tendency-mean, median, mode. Partition values – quartiles and percentiles. Measures of dispersion – range, interquartile range, variance and standard deviation, Coefficient of variation, Measures of skewness and kurtosis, Box plots

Correlation- Scatter plot, Karl Pearson's correlation and Spearman's rank correlation. Regression Analysis –simple linear regression

Learning outcome:

Students shall learn how to compute and interpret measures of central tendency and spread of data, analyze methods for examining central tendencies and dispersion

Unit 3: Inferential Statistics 10 hrs

Testing of hypothesis –framing a hypothesis-–research hypothesis and statistical hypothesis, types of errors, size, power, p-value, and statistical significance.

Parametric test: One sample z & t-test, paired t- test, 2-sample (unpaired) t-test, Analysis of Variance (ANOVA)- One way ANOVA.

Non parametric tests – chi-square test , Mann –Whitney test, Wilcoxon signed rank test, Kruskal –Wallis test.

Learning outcome:

Students shall be able to develop null and alternate hypotheses to inferential problems, choose the right test for a given research problem, analyze data and interpret the result. They shall be able to solve the problems by applying various parametric and non parametric tests.

BIOINFORMATICS

Unit 4: Introduction 10 hrs

Goals, applications, and limitations of Bioinformatics, DNA and protein sequence databases, Structure databases, programming in Python.

Learning outcome:

Students will understand bioinformatics and computational biology. They will be able to perform programing in Python and parsing text files

Unit 5: Sequence Alignment, Searching, and Phylogenetics 10 hrs

Evolutionary Basis of sequence alignment, Global alignment and local alignment, Gap penalties, Scoring matrices, Dynamic programming methods: Needleman- Wunsch and

Smith - Waterman algorithm, Database similarity search - BLAST. Multiple sequence alignments - Progressive and Iterative alignment methods, Molecular evolution and phylogenetics, Phylogenetic trees, Molecular clock theory, Maximum Parsimony, Methods of tree construction

Learning outcome:

Students shall be able to understand Needleman-Wunsch and Smith- Waterman algorithm, run standalone BLAST

Unit 6: Structural Bioinformatics 8 hrs

Ramachandran plot, protein secondary structure prediction, Chou-Fasman and GOR method, Neural networks, Protein three dimensional structure prediction: Homology modeling and protein Threading, Molecular visualization, Computer aided drug design, Docking and QSAR

Learning outcome: Students will be able to understand phylogeny trees and use MEGA software

Recommended books for reference:

1. Bernard Rosner (2011): Fundamentals of Biostatistics (7^{th} Edition)- Brooks/Cole
2. B.K. Mahajan, Arun Bhadra Khanal (2008): Methods in Biostatistics for medical students and research workers (7^{th} Edition), Jaypee Brothers Medical Publishers.
3. Wayne W. Daniel and Chad L. Cross (2012); Biostatistics- A Foundation for Analysis in the Health Sciences (7^{th} Edition), Wiley.
4. Olive. J. Dunn and Virginia A. Clark. (2009)- Basic statistics: A primer for the Biomedical Sciences, Wiley.
5. Xiong J, Essential Bioinformatics, Cambridge University Press (2006)
6. Mount D W, Bioinformatics - Sequence and Genome Analysis, Cold Spring Harbour Laboratory Press (2001)
7. Ghosh Z, and Mallick B, Bioinformatics – Principles and Applications, Oxford University Press (2008)
8. Higgins, D. and Taylor, W., Bioinformatics: Sequence, Structure and Databanks – A Practical Approach, Oxford University Press (2000).
9. Systems Biology: Definitions and Perspectives by L. Alberghina H.V. Westerhoff., Springer.2005

Course Name: SYSTEMS BIOLOGY AND OMICS TECHNOLOGY
Course Code: APBS303
Credits: 4 (56 hrs)

Course Objectives

At the end of the course the student will be able to gain knowledge on

- Basics of gene expression analysis and genome sequencing technologies
- Technologies to analyse transcriptome and epigenome
- Basic of proteomics experimental pipeline and data analysis
- Basics of metabolomics experimental workflow and data analysis
- Multi-omics data integration

Unit-1: Genomics 12 hrs

Sanger sequencing-principle, methodology and applications, History of genome sequencing, Human Genome sequencing project; Analysis of gene expression- qPCR, northern blot, southern blot; exome sequencing; DNA microarrays; Copy number variation, sequence repeats, SNV, haplotype, and their relevance in diseases, Next Generation Sequencing (NGS) technology, Whole genome - de novo sequencing, comparative genomics, metagenomics

Learning outcome:
The student will gain knowledge of Sanger sequencing and know about methods to analyse gene expression and whole genome sequencing

Unit-2: Transcriptomics and Epigenetics 10 hrs
RNA-seq analyses, Transcriptome profiling; RNA sequencing; small RNA sequencing; Differential expression, Alternate splicing, Epigenetics, CpG island methylation, Histone acetylation, Bisulfite sequencing

Learning outcome:
The student will gain knowledge of different technologies to analyse transcriptome and epigenome

Unit-3: Proteomics 12 hrs
Basics of chromatography, mass spectrometry – ionization methods (MALDI, electrospray, mass analysers, protease digestion, peptide mass fingerprinting, tandem mass spectrometry, sample preparation strategies, fractionation strategies; Protein sequence and spectral databases/ libraries, de-novo sequencing, search algorithms/engines, Proteomic data repositories, Introduction to quantitative proteomics and Targeted proteomics

Learning outcome:
The student will gain knowledge on the basics of proteomics experimental pipelines and data analysis

Unit-4: Metabolomics 12 hrs

Metabolomics-an overview, basic sample preparation strategies- extraction, derivatization, Introduction to small molecules and lipidomics; Targeted Vs Untargeted metabolomics; development of targeted assays for small molecules; Metabolic pathways, metabolite profiling, inborn errors of metabolism

Learning outcome:
The student will gain knowledge on the basics of metabolomics experimental workflows and data analysis

Unit-5: Data analysis and Multi-omics data integration 10 hrs
Genomic, transcriptomic, proteomic and metabolomics data file format and standards, Bioinformatics tools for data analysis, curation and gene accession mapping, Quality control for data integration, Analysis and visualization, gene set Enrichment analysis, Pathway analysis, Network analysis, Proteogenomics-concepts.

Learning outcome:
The student will gain knowledge on the various tools and databases for omics data analysis and multi-omics integration

Recommended books for reference:

1. Brown TA (2010). Gene cloning and DNA analysis: An introduction. Wiley-Blackwell.
2. Green MR, Sambrook J (2012). Molecular cloning – A laboratory manual. Cold Spring Harbor Laboratory Press.
3. Karp G (2009). Cell and molecular biology: Concepts and experiments, 7th edition. John Wiley & Sons.
4. Lodish H, et al. (2008). Molecular cell biology. W. H. Freeman.
5. Miller K, Levine J (2010). Biology. Pearson.
6. Wilson K, Walker J (2010). Principles and techniques of biochemistry and molecular biology, 7th edition. Cambridge University Press.
7. Baxevanis AD, Ouellette BFF (2005). Bioinformatics – A practical guide to the analysis of genes and proteins (3rd edition). Wiley India.
8. Fan TW-M, et al. (2012). The handbook of metabolomics. Humana Press
9. Gross JH (2011). Mass spectrometry – A textbook. Springer.
10. Kulkarni S, Pfeifer J (2014). Clinical genomics. Academic Press.
11. Leung H-CE (2012). Integrative proteomics. InTech Publishers.
12. Lindon JC, et al. (2007). The handbook of metabonomics and metabolomics. Elsevier
13. Primrose SB, Twyman RM (2006). Principles of gene manipulation and genomics. Blackwell Publishing.
14. Reece RJ (2004). Analysis of genes and genomes. John Wiley & Sons Ltd.
15. Simpson R (2002). Proteins and proteomics: A laboratory manual. Cold Spring Harbor Laboratory Press.

Course Name: GENETIC ENGINEERING
Course Code: APBS304
Credits: 4 (56 hours)

Course Objectives:

At the end of the course the student will be able to

- Learn about the use of restriction endonuclease and cloning vectors
- Learn about PCR, primers, design primers, site directed murtagenesis, chimeric proteins.
- Explain different types of cloning and cloning vectors, contruct cDNA libraries
- Screen libraries using nucleic acids, clone genes using PCR and study importance of promoters
- Learn about the expression and purification of recombinant proteins and methods of gene manipulation

Unit-1: Enzymes and Vectors in gene cloning 12 hrs

Restriction enzymes, methylases, DNA polymerases, reverse transcriptase, terminal transferase, alkaline phosphatase, polynucleotide kinase, ligase, DNase and RNase, Plasmid vectors, Vectors based on the lambda Bacteriophage, Cosmids, M13 vectors, Expression vectors, Vectors for cloning and expression in Eukaryotic cells, Super vectors, YACs and BACs. Structural and functional organization of plasmids, plasmid replication, stringent and relaxed plasmids, incompatibility of plasmid maintenance. Lambda phage vectors.

Learning outcome:
Students will learn about types of restriction enzymes and different types of cloning vectors and methods to clone genes of interest for increased expression.

Unit-2: Polymerase chain reaction 12 hrs

PCR, gene isolation by PCR, primer design – gene specific primers, nested primers, degenerate primers, optimization of PCR components and thermal conditions, PCR set up with proper controls, types of PCR – inverse PCR, multiplex PCR, nested PCR, TAIL PCR, LAMP, semi quantitative RT-PCR, real-time PCR with SYBR and Taqman probe, site directed mutagenesis- PCR based site directed mutagenesis, Random mutagenesis, Use of Phage display techniques to facilitate the selection of mutant peptides, Gene shuffling, production of chimeric proteins.

Learning outcome:
Students will learn concepts and types of PCR and will be able to design primers and execute PCR experiments. They would learn application of PCR for site directed mutagenesis and chimeric proteins

Unit-3: Gene Cloning Methods 12 hrs

Cohesive end cloning, cloning using adapters, linkers and homopolymer tailing, TOPO cloning, cloning of PCR products – TA cloning, blunt end cloning, cloning with added restriction sites, GATEWAY cloning, ligation free cloning, Construction of cDNA library, subtractive cDNA library, normalized cDNA library, genomic DNA library.

Learning outcome:

Students will learn about different types of cloning and cloning vectors. They would understand methods to construct cDNA library.

Unit-4: Gene and Promotor isolation 10 hrs

Methods of screening the libraries using nucleic acid and antibody probes, functional screening, screening by complementation, cloning of genes by PCR, RT-PCR, RACE-PCR, artificial gene synthesis, constitutive and inducible promoters, tissue specific promoters, promoter identification from gene expression data, promoter deletion studies, reporter genes for promoter deletion studies.

Learning outcome:

The students will gain knowledge on screening the libraries using nucleic acid and antibody probes, Cloning genes by PCR, RT-PCR, RACE-PCR & Identification of promoters, types of promoters, promoter deletion studies.

Unit-5: Genetic Engineering of living organisms 10 hrs

Expression and purification of recombinant proteins in E.coli, yeast, Baculovirus, animal cell lines, transgenic plants and transgenic animals, Gene manipulation (silencing, epigenetic modification, types of small non translated RNA),Changing genes: site-directed mutagenesis and Protein engineering: Primer extension, PCR based site directed mutagenesis, Random mutagenesis, Use of Phage display techniques to facilitate the selection of mutant peptides, Gene shuffling, production of chimeric proteins. Ethical considerations.

Learning outcome:

Students would learn about the expression and purification of recombinant proteins. They would be introduced to the methods of gene manipulation, gene shuffling, chimeric proteins, site directed mutagenisis and protein engineering.

Suggested books

1. Ausubel. Short Protocols in Molecular Biology. Wiley. 2002.
2. Brown. Essential Molecular Biology. Vol. I & II. AP Publications. 2000.
3. Brown, Gene Cloning - An Introduction Stanley Thornes. 1995.
4. Glick & Pasternak Molecular Biotechnology ASM Press 1998.
5. Kracher Molecular Biology - A Practical Approach.
6. Krenzer & Massey Recombinant DNA and Biotechnology ASM Press, 2000.
7. Micklos & Freyer DNA Science CSHL Publications. 2000.
8. Primrose. Molecular Biotechnology. Panima Publications 2001.
9. Robertson. Manipulation & Expression of Recombinant DNA. AP Publications, 1997.
10. Sambrook Molecular Cloning CSHL2001.
11. Watson. Recombinant DNA Freeman Publications.

Course Name: CELL CULTURE TECHNIQUES
Course Code: APBS305
Credits: 3 (42 hours)

Course Objectives:

At the end of the course the students shall be able to:

- Familiarize with various aseptic techniques, instrumentation and implementation of sterile practices for cell culture.
- Understand the composition and applications of various types of media used for cell culture
- Elaborate on characteristics of primary/established cell lines and know various cell based assays such as cytotoxicity, clonogenic assays etc.
- Elucidate the applications of cell culture in genetic engineering with therapeutic implications
- Assess the role of embryonic and adult stem cells in biological systems

Unit-1: Basics of animal cell culturing 10 hrs

Structure and organization of an animal cell, Types of animal cell culture – cell culture, organ/tissue culture, organotypic culture and histotypic culture, Infrastructure, equipments and materials needed for animal cell culture technology, ensuring sterility in cell culture laboratory, Mycoplasma: Detection and Control, normal contaminants in cell cultures.

Learning outcome:
Students shall be able to elucidate the cellular organization and learn how to identify the common contaminants. They shall also be able to familiarize with various aseptic techniques and instrumentation employed in cell culture laboratory.

Unit-2: Media components and their significance 13 hrs

Introduction to the balanced salt solutions and growth medium, Brief discussion on the chemical, physical and metabolic functions of different constituents of culture medium, Role of carbon-di-oxide and role of serum and its supplements in maintaining cells in culture medium, Serum and protein free defined media and their application.

Learning outcome:
Students shall be able to learn the composition of media, supplements and their functions in cell growth and differentiation

Unit-3: Basic techniques of mammalian cell culture 13 hrs

Primary and established cell lines, Culturing and Sub-Culturing of Animal Cells , Biology and characterization of the cultured cells, measuring parameters of growth. Maintenance of cell culture, Cell Line Preservation, Cell synchronization, Cell Line Characterization, Cell

transformation, Chromosome Spreading and Karyotype Analysis, Cloning of Animal Cells, Measurement of viability and cytotoxicity, Apoptosis – characteristic features and molecular mechanisms, Measurement of cell death

Learning outcome:
Students shall be able to learn the concepts cell line maintenance and shall be able to distinguish the cell types. They shall also be able to elaborate on the cytotoxicity assessments

Unit-4: Engineering animal cells 10 hrs

Somatic cell genetics, Cell culture based vaccines, Genetic engineering of mammalian cells in culture, Scaling up of animal cell culture, Stem cell cultures – embryonic and adult stem cells and their applications.

Three dimensional culture and tissue engineering, Applications of animal cell culture technology -heterologous, Primary culture/CEF culturing, Protein Expression. Downstream processing of products from cell culture.

Learning outcome:
Students shall be able to elucidate the applications of cell culture in vaccine preparation and genetic engineering. They will also be able to distinguish between embryonic and adult stem cells and their applications in cell therapy.

Unit-5: Applications of animal cell culture 10 hrs

Three dimensional culture and tissue engineering, Applications of animal cell culture technology -heterologous, Primary culture/CEF culturing, Protein Expression. Downstream processing of products from cell culture.

Learning outcome:
Students shall be able to conceptualize the basics and applications of three dimensional culturing. Students shall be able to know the usage of cell culture systems in recombinant protein expression, purification and commercial applications thereof.

Recommended books for reference:

1. Freshney RI. Culture of animal cells: a manual of basic technique and specialized applications. 2015. John Wiley & Sons.
2. Masters JR. Animal cell culture: a practical approach. 2000. Oxford Publishers.
3. Clynes M. Animal cell culture techniques. 2012. Springer Science & Business Media.
4. Wilson L, Matsudaira PT, Mather JP, Barnes D. Animal cell culture methods. 1998. Academic Press.

Course Name: BIOSTATISTICS AND BIOINFORMATICS
Course code: APBS306
Credits: 2 (56 hours)

SL. No	Laboratory Exercises:	Hours
	BIOSTATISTICS	
1.	Tabulation and data visualization	4
2.	Descriptive statistics for categorical data and continuous data-1	4
3.	Descriptive statistics for categorical data and continuous data-2	4
4.	Correlation & Regression analysis	4
5.	Testing of hypothesis- Testing for single mean and comparision of means	4
6.	Non parametric tests (chi-square test, Mann- Whitney test, Wilcoxon signed rank test, Kruskal- wallis test)	4
7.	One way analysis of variance	4
	BIOINFORMATICS	
1.	Basics of programming	4
2.	DNA and protein sequences and PDB file formats	4
3.	Local and global sequence alignment	4
4.	BLAST	4
5.	Phylogenetic tree construction	4
6.	Homology modelling and Visualization of 3-D structure	4
7.	Docking	4

Course Name: SYSTEMS BIOLOGY AND OMICS TECHNOLOGY
Course code: APBS307
Credits: 2 (56 hours)

SL. No	Laboratory Exercises:	Hours
1	Next Generation Sequencing data – quality control, alignment and analysis	8
2	Protein extraction strategies for varied biological samples	4
3	Normalization techniques for quantitative proteomics	4
4	Liquid chromatography-based fractionation of proteins	4
5	Stop And Go Extraction (C18-based) for mass spectrometry	4
6	Proteomic data analysis- Search algorithms, False Discovery Rates, Parsimony rules	8
7	Extraction techniques for Metabolomics.	4
8	Metabolomics Data analysis – identification of molecular features, metabolite identification; structural confirmation of metabolites.	8
9	Integrated OMICS data analysis – Proteogenomics.	4
10	Biological interpretation of OMICS data- Gene Set Enrichment Analysis, Pathway analysis, Network analysis	8

Course Name: CELL CULTURE TECHNIQUES
Course code: APBS308
Credits: 2 (56 hours)

SL. No	Laboratory Exercises:	Hours
1	Sterile Techniques	4
2	Preparation Different media used in cell culture	4
3	Seeding of the cells and passaging using established cell lines	4
4	Culturing adherent and suspension cells, observations, photomicrography	8
5	Cell counting and viability (SRB, Trypan blue dye exclusion)	8
6	Cryopreservation of cells	4
7	Cytotoxicity assays (MTT assay)	4
8	Clonogenic assay for cell proliferation	8
9	Lymphocyte culture	4
10	Cell cycle analysis	8

SEMESTER –IV

Scheme

Course Code	Details	Duration	Credits
APBS401	Project work	14 weeks	24